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Great Lakes Pollution Prevention Initiative

METAL FINISHING POLLUTION PREVENTION GUIDE

Prepared by:
Canadian Association of Metal Finishers
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Ontario Ministry of Environment and Energy

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AESF APMA CAMF mfsa Ontario

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NOTICE

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PREFACE

Metal finishing facilities can generate large quantities of both hazardous and nonhazardous wastes. These wastes result from cleaning, pickling, plating, conversion coating and other finishing operations. Reducing these wastes at the source will benefit the metal finishing industry and reduce raw material needs and disposal costs. It will also lower the regulatory cost and liability associated with hazardous waste disposal. In fact, some companies have decided to set a zero-water-discharge long term goal.

This manual provides guidance to metal finishers for incorporating pollution prevention planning into their everyday business activities. If followed, the principles outlined in the guide will prepare the metal finisher for the future from both business and environmental perspectives. This guide provides procedures to assess pollution concerns and help a pollution prevention team in identifying, prioritizing and implementing solutions to pollution problems.

ACKNOWLEDGEMENTS

Many organizations and individuals cooperated in the preparation of this Guide. We include and thank everyone who devoted many days to help plan, write, edit and reedit this manual. We hope it will become a useful tool for all metal finishers.

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EXECUTIVE SUMMARY

Operating a metal finishing business requires a great deal of cooperation among owners, management, employees, government and the community within which they live. Society is concerned with the amount and the long term effects of pollution entering the air, land and water environment. Government utilities, industrial companies, residential groups and individuals must ensure that all products from one's operations are safe and pose no threat to the receiver. Within 10 years, it is expected that all customers will demand that their suppliers be in total control of their operations. The scope of the control will encompass and require a detailed knowledge of all elements, chemicals, metals, processes and outputs including those that can pollute if not controlled.

Within each company, owners, management and employees must work together to assess all aspects of their operations. The result will be a detailed knowledge of the process elements. This effort can have many benefits. For example, it eases meeting ISO 9000 standards and adherence to current and future legislation.

Detailed process documentation will help identify opportunities for waste reduction. Once identified, changes to the plant's systems should be evaluated, planned and carried out. Compare the elements causing damage to the environment with those identified by government and research groups. This results in informed decisions about needed changes.

- Easy and profitable improvements should be done first.
- More difficult processes can be examined for discussions with customers and suppliers.
- The long term objectives are to stop using troublesome process elements and where possible switch to less harmful activity.
- Where this is not possible, then the other options of reuse and recycling must be attempted.
- Landfilling of hazardous wastes remains the last resort and will become less acceptable in future years.

The key to carrying out this program in any company is the decision by senior company management that **it must be done**. Company management must begin to provide long term support to the principles set out in this Guide. Once the process is started, company personnel will become more confident in their ability to manage their total environment. The Guide will provide a record of their operations and efforts to control their work environment.

Management's first hurdle is to appoint a formal environmental team for this effort and then start carrying out the major Guide components. The benefits to your company will amaze you and satisfy those around you.

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THE METAL FINISHING POLLUTION PREVENTION PROJECT

The Metal Finishing Pollution Prevention Project was initiated in January 1993. It is a cooperative effort by governments and industry to promote the development and application of pollution prevention programs in the metal finishing industry. Participants in the project include the Canadian Association of Metal Finishers (CAMF), the Ontario Branches of the American Electroplaters and Surface Finishers Society (AESF), the Automotive Parts Manufacturers' Association (APMA), the Canadian Chapter of the Metal Finishing Suppliers Association (MFSA) and the Federal and Ontario Governments. The project is voluntary in nature and is supportive of participating company management plans, federal and provincial strategies and long term competitiveness in the North American economic environment.

A major benefit of the project is that it actively contributes towards multimedia pollution prevention consistent with the Great Lakes Canada/United States programs and the Ontario Ministry of the Environment's Pollution Prevention Strategy. The project manual provides a methodology with supporting tools for the formulation of pollution prevention plans to reduce toxic substances entering the Great Lakes Basin.

A Task Force managed the project. It was responsible for developing and promoting a strategy for identifying, planning, carrying out, monitoring, reporting and verifying toxic substance pollution prevention plans developed and carried out by member companies of the CAMF, AESF and APMA. Case studies were conducted at Dura-Chrome Limited, Wallaceburg, Monroe Auto Equipment, Owen Sound, Menasco, Oakville and Torcad, Toronto to evaluate the effectiveness of the methodology and tools.

The Ontario Ministry of the Environment and Energy and Environment Canada - Ontario Region provided funding for the project. The Wastewater Technology Centre, Burlington provided technical expertise in the development and evaluation of the methodology and in the preparation of the case studies.

INTRODUCTION TO POLLUTION PREVENTION PLANNING

Pollution prevention is

> "Any action which reduces or eliminates the creation of pollutants or wastes at the source, achieved through activities which promote, encourage or require changes in the basic behavioral patterns of industrial, commercial and institutional generators or individuals". (MOEE, Pollution Prevention Planning Guidance Document and Workbook, 1992)

Pollution prevention is not a new idea. Simply put, pollution prevention looks at waste as a loss in raw material (including water and energy), which is equivalent to throwing money down the drain. From a business perspective, having little or no waste is much more efficient and less costly than treating and disposing of those wastes.

To those of you who are successful in the metal finishing industry, increased levels of effort may seem unwarranted. Stricter regulations are in place; waste installations are coping with toxic effluent; resource costs are stable. However, some customers, particularly, in the automotive and aerospace industries, have come to expect even higher standards from their suppliers. Recently, North American automotive manufacturers adopted the ISO (International Standards Organization) 9000 standards for themselves and their suppliers as the basis for future management. ISO registered companies must be in total control of all facets of their operations.

Pollution prevention planning is done to shift the environmental management philosophy at a facility from the reacting mode to the anticipating mode. Planning moves the company from expensive "end-of-pipe" treatment and disposal to internal recycle of streams and pollution prevention (control at the source). Environmental management at facilities focuses on prevention techniques (chemical substitution, process change, internal recycling) and external recycle/reuse options with less emphasis placed on treatment and remediation.

The pollution prevention planning process is a continual evaluation of how to do business in all functional areas. It requires a strong commitment from the senior facility management to be successful. The process needs cooperation and personal commitment from all departments. Most important is a committed pollution prevention champion to maintain momentum. Staff who participate in the planning exercise will vary from plant to plant, but as a minimum, managers, technical staff and process and treatment system staff should be involved. The process can work as a training program to upgrade the skills of all operators.

The approach taken by this guide is similar to Total Quality

Management (TQM) and built on the idea of continuous improvement. This document was written to simplify the process of pollution prevention planning as it applies to metal finishers. The strategy cuts through barriers to make your business less wasteful, more efficient and more successful. This guide outlines "how to evaluate and make changes to the current metal finishing plant systems."

The methodology of pollution prevention planning is as follows:

- Pollution sources are identified.
- Less harmful materials and processes are actively sought out and implemented to eliminate/ reduce impact of pollution sources.
- Harmful process effluents are better managed. Reuse and recycling are preferred routes. The least desirable approach is to send toxic wastes to landfill storage.

Users embracing the principles, procedures and record keeping approach outlined in this guide will benefit.

- They will reduce costs as they analyze their operation looking for better alternatives.
- They can show due diligence to banks, regulatory authorities and their neighbours.
- They will minimize third party liabilities and increase the value of their assets. Future generations and owners of their business or property can be assured of minimal pollution above, in, on, and/or under the premises.
- Insurance risks and premiums should be reduced.
- Best of all, the environment is protected.

The use of this guide is voluntary and should command your careful attention. It represents a serious effort by the federal and provincial governments to redirect their emphasis from enforcement of "end-of-pipe" regulations to voluntary source control. This approach supplies the basis for metal finishers to figure out their own priorities with respect to pollution control. Ontario metal finishers tested the document in case studies which document the success that can be realized by following this program.

Take a serious look at the guide. Pollution prevention programs benefit the metal finishing industry through improved plant safety and quality control and enhanced environmental health. To get a better idea of what pollution prevention is about, examine the case studies provided in Appendix G.

OVERVIEW OF THE POLLUTION PREVENTION PLANNING MANUAL

This manual outlines a systematic, cyclic eight step pollution prevention planning process. It is built on the premise of continuous improvement. It also helps metal finishers in promoting pollution prevention activities in their plants. The focus is on the reduction of toxic substances used, generated or released from the metal finishing plant. The outcome of the process is a comprehensive, multimedia pollution prevention plan. The steps are essential for a successful pollution prevention program.

The eight steps are as follows.

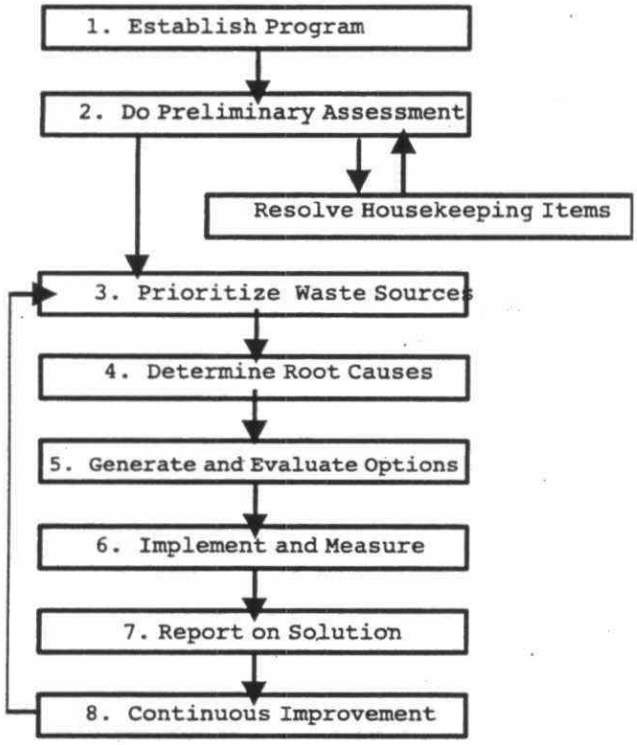


Figure 1. The Pollution Prevention Planning Process

1. Initiate the pollution prevention program
2. Assess the way business is currently conducted and identify waste sources
3. Set priorities for the wastes for further consideration
4. Find out root cause(s) of waste
5. Identify and assess potential pollution prevention solutions
6. Carry out and measure pollution prevention solutions
7. Report on the success of the pollution prevention program
8. Ensure continuous improvement.

This step-by-step approach provides a practical set of procedures to incorporate pollution prevention planning into business plans.

The steps are discussed in detail and accompanied by Forms (see Appendix D) that assist in directing data collection. Where forms are available, they are identified by a shadowed box in the right margin. The forms evolved from studies of typical metal finishing facilities and should prove suitable for use in most metal finishing operations.

The guide has been written to allow facility personnel to go through the process one step at a time. Literature references and more detailed information on the tools and techniques can be found in the other Appendices. Appendix F provides a checklist and knowledge

testing approach for key activities within the process.

The manual uses examples from the "Peerless Plating Company" to illustrate the practical aspects of the pollution prevention planning exercise. The completion of the appropriate forms by "Peerless" provides helpful information on the tools and techniques.

The pollution prevention planning process requires a strong commitment from the senior facility management to be successful. Cooperation and personnel commitment from all departments is needed. Most importantly the process needs a champion to keep it rolling. Often the person that takes the time to read this manual will also take on this role.

For facilities with limited resources and time to commit to the process, technical assistance is available from outside the facility. Engaging an outside consultant can provide the incentive to keep the momentum of the process going. The everyday operation of the plant does not constrain external personnel. They identify problem areas that are usually forgotten or taken for granted by facility staff. Consultants in pollution prevention can provide in-house training to the facility staff so that in the next planning cycle staff can carry out the plan themselves.

Having gone through the process once, the company realizes the benefits and will commit the resources to the planning process in the second and subsequent cycles. Many agencies can provide technical assistance in pollution prevention. Government incentive programs are available to provide funds for carrying out pollution prevention projects in a facility.

No matter which approach the facility decides to embark on to implement their pollution prevention program, it is important that they make the planning process their own. If appropriate management or problem solving tools or methods are currently in use at the facility, they should be incorporated into the pollution prevention planning exercise. The idea is to systematically look at the way the company's business is done and to rank any inefficiencies for further examination using pollution prevention. Appendices A and B provide information on terminology and explanations of acronyms and concepts.

STEP 1. ESTABLISH A POLLUTION PREVENTION PLANNING PROGRAM

Purpose	· Establish a pollution prevention program within a facility
Objectives	· Obtain management commitment and participation · Define objectives and responsibilities · Define, obtain and allocate resources/personnel · Empower employees · Involve stakeholders
Products	· Team **(Example 1A)** · Environmental Policy Statement **(Example 1B)** · Planning framework and schedule **(Example 2)** · Communications plan: for internal and external use **(Example 3)**
Timing	· Effort: 3-4 person days · Duration: about 1 month
Who	· Champion; Team; External resources
Roles	· Champion: leads the team; provides enthusiasm · Team: does/delegates the tasks; agrees upon responsibilities · External Resources: consultant or other person (supplier, industry association) can provide objective viewpoint, facilitation, and/or specific expertise
Tools	· Forms 1A, 1B and 2 **(Appendix D)** · Team building **(Appendix B)** · Project management **(Appendix B)** · Communications mechanisms

INTRODUCTION

This step describes how to initiate a pollution prevention planning program within a facility. It addresses obtaining management commitment, organizing a team, setting the objectives and schedules for the planning program, and preparing a communication plan. Although cooperation from all levels of the organization is essential, it is senior management commitment that will ultimately decide the success of the program. It is also essential to the success of the program that those people not directly involved in the planning process be kept informed of the status of the project. The changes that will take place because of this program will affect everyone in the plant and it is important to make this clear at the onset.

OBTAIN MANAGEMENT COMMITMENT

Senior management commitment is initially shown by the number of people and resources allocated to the program. The experience of many companies has been that pollution prevention pays, for reasons that include reduced costs associated with both material purchases and waste management. It must be recognized, however, that there is an initial labour cost that is borne in organizing and carrying out a pollution prevention program. The multiple step process attempts to minimize this initial cost and to accelerate implementation; nevertheless, there is an up-front resource requirement that requires management's approval. It will be helpful to use case studies to illustrate the benefits of pollution prevention planning. Appendix G provides case studies.

ESTABLISH THE TEAM

The planning process works best if it done by a team consisting of people with responsibilities from all areas in the plant. Although the number of people participating on the team depends on the size and complexity of the facility, a team leader or champion should be designated. This individual does not have to be the most senior person in the company, but he/she must have authority delegated by senior management to take charge of the program. It is advantageous if the leader is familiar with all aspects of the facility's operations and has technical and environmental knowledge.

Form 1-A
Page D-3

The most successful programs use a "cross-functional team approach". That is, personnel from different operations and levels within the organization work together to address problems. One individual rarely has enough knowledge and experience to keep track of everything that goes on with an operation or process. Even with a small facility, the owner-operator should include shop-floor staff. They can confirm the actual practices used. As the size of the operation increases, it will be appropriate to enlarge the team. Representation from purchasing and accounting may be helpful in tracking costs. Maintenance and quality control may also bring different perspectives to the discussions. **Form 1-A (Appendix D)** offers a useful template for identifying team members and their responsibilities.

External personnel may often complement the internal staff by providing expertise to overcome team weaknesses. Environmental consultants may offer auditing expertise and knowledge of pollution prevention methods and technologies, environmental laws and regulations. Quality or general management consultants may provide expertise in recognizing waste and defects and provide methods of acting upon the findings. In addition, consultants may be aware of solutions to your problems. On the negative side, external people will be unfamiliar with your facility's operations, and sometimes

they may not have adequate knowledge of the process operations. On balance, the addition of an external person should prove valuable if the team has specific weaknesses that the consultant can overcome ***(Example 1A).***

The first meeting of the team should be used to ensure all key areas of the plant are represented. Assign each team member a list of responsibilities. Responsibilities can include the provision of data and/or information on processes, cost information, senior management liaison and input from unions. Areas of responsibility not fulfilled by the team should result in an invitation to other staff members to join the team or to the hiring of a consultant.

Peerless Plating Pollution Prevention Team		
Team Member	**Company Position**	**Responsibility**
John Doe	General Manager	Oversee program, representative of company, final decision
Peter Smith	Plant Manager	Daily operation, communication to employees, cost control
Sarah Jones	Lab & Quality Assurance	Testing, documentation, monitoring, sample collection and analysis
(Others as needed:) Tony Black Jean Small Betty Murphy Paul Brown Joe White Arthur Jackson	 Production Representative Office Manager Safety and Health Officer Shift Foreman Plating Line Operator Warehouse Worker	Information collection and input into program as required
ABC Consultants	"Advisors"	"Third Party" advisors or facilitators of Pollution Prevention program

Example 1A. Team Members and Responsibilities [Form 1A Appendix D]

DEVELOP A MISSION AND POLICY STATEMENT

With the team in place, the first task should be to develop a mission statement. The mission statement should clearly state the reason that the team exists, and its fundamental focus. The team should examine the company's environmental policy statement, or if one does not already exist, develop one. The policy statement should state the organization's values,

Form 1-B
Page D-3

Environmental Policy Statement

Peerless Plating is committed to protecting the environment and to incorporating environmental considerations into every aspect of our daily operations. We are pledged to preventing pollution by eliminating or reducing the generation of all wastes and minimizing our use of resources throughout our operations. Environmental protection is the responsibility of everyone at Peerless Plating and all employees are encouraged to suggest means by which pollution may be prevented in their work area.

Objectives

1. *Eliminate sludge production.*
2. *Optimize the operation of the Waste Treatment Plant.*
3. *Obtain data on upstream sources.*
4. *Minimize water intake and recycle water where possible in the plating process.*
5. *Develop a "Waste Treatment Design and Operation" manual for plant personnel.*

Priorities

1. *Immediate reduction in toxic metal releases to the sanitary sewer and hazardous waste sludges.*
2. *When financial resources are available, immediately undertake pollution prevention tasks.*
3. *Ensure Waste Treatment Plant operates within favourable operating parameters.*
4. *Economics will not be the primary factor that influences potential actions.*
5. *Effective payback within 12 months will be encouraged.*

Example 1B Environmental Policy Statement, Program Objectives and Priorities [Form 1B Appendix D]

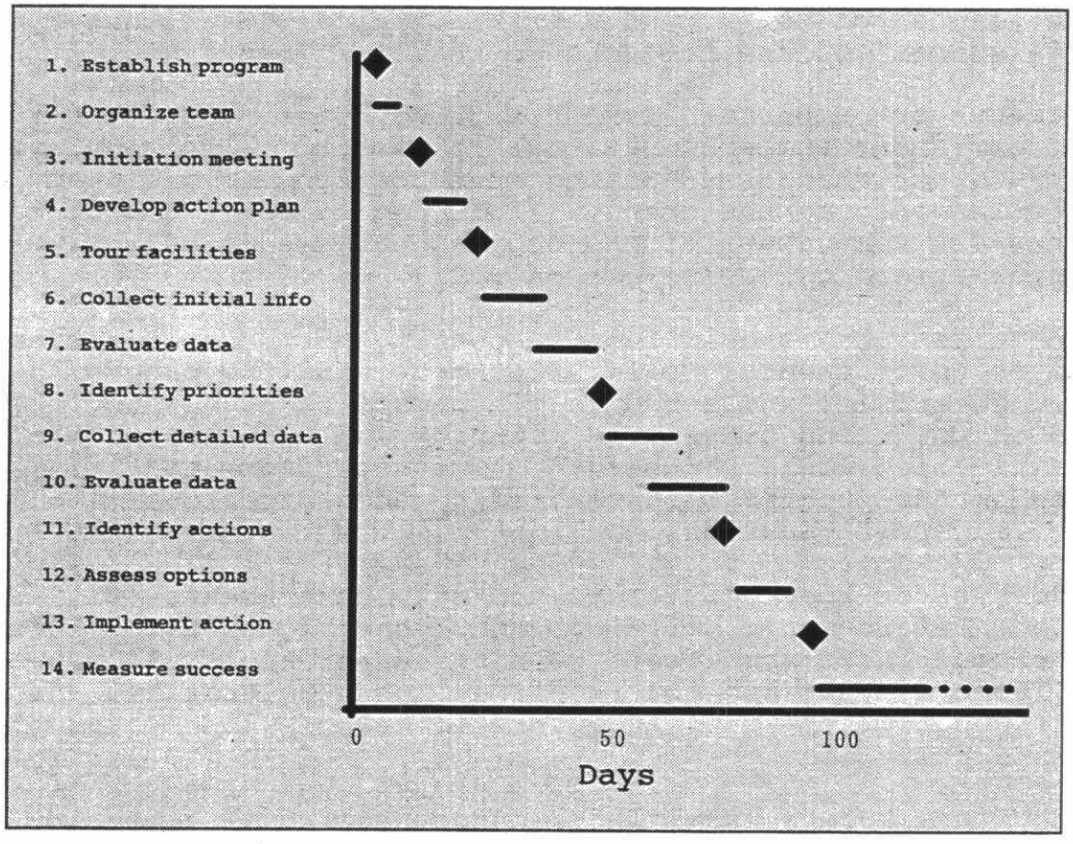
beliefs, and guiding principles about environmental performance. Since pollution prevention is the continuous improvement aspect of environmental performance, it should be clearly outlined in the environmental policy statement. Develop the general objectives and priorities of the program from the Environmental Policy Statement. The team should identify these objectives and priorities in their initial meeting. Post them to inform all company staff about the pollution prevention program. **Form 1-B (Appendix D)** offers a template for this activity.

Example 1B on page 18 provides a sample policy statement and the project objectives and priorities. It says that the ideas of pollution prevention are important to the company and identifies those responsible for protecting the environment.

DEVELOP A SCHEDULE AND DETERMINE RESOURCES REQUIRED

Form 2
Page D-5

The team should develop a schedule for carrying out the program. Simultaneously, the team should decide the resources required to get the program under way. The schedule and resources are closely related. The



Example 2. Peerless Plating Schedule [Form 2 Appendix D]

schedule should clearly outline expected milestones for the program. While agreeing upon these milestones, the team should also agree upon the allocation of resources for the program ***(Example 2 on page 19)***.

DEVELOP A COMMUNICATIONS PLAN

The team should develop a plan for communicating on their progress to two audiences. The first audience is senior management, who require reports on resource expenditures, issues addressed, timing of activities and accomplishments. The second audience consists of the rest of the organization, who have more general information needs. The communication plan should fit in with the existing communications network (if there is one) and the company style. For example an employee newsletter may be used to track the progress of the project. Using the existing communication network will ensure that the projects become everyday issues within the business plans of the company. As a means of raising the awareness of all employees to the waste issue, it may be beneficial to look at the experience in the health and safety field. Many companies post the number of hours worked without injury in a location that is visible to employees and visitors alike. On a parallel theme, waste quantities generated/ discharged/ deposited could be posted allowing all employees to witness the success of the projects in reducing wastes.

Accomplishments are important for this group, since they tend to reinforce commitment and encourage participation. Also, employees affected by future changes resulting from the program will want to participate in managing the change. This can be adapted most easily if employees are kept aware of the program through an effective communication system ***(Example 3 on page 21)***.

The communication plan should include posting of the team membership, the company's Environmental Policy Statement, and the program's objectives, priorities and schedule. A newsletter outlining the principles of pollution prevention planning and a description of some proposed activities would be useful. A request from staff for suggestions on the program is essential to encourage their cooperation and participation.

It may be useful to keep regulators and city departments (e.g. Public Works and the Environment, Buildings and Inspections, etc.) informed about the project. In some cases permits and/or approvals may be necessary. Even if they are not required, the regulator will have on record an account of the diligence that is being taken by the plant in preventing pollution.

In addition, it may be worthwhile to inform the local community about the program especially if it will result in improved conditions for your neighbours.

At Peerless Plating the team decided that there would be key opportunities for communicating with senior management and other employees.

Communication to the employees would be printed in their quarterly company newsletter. The Plant Manager was assigned the responsibility of ensuring that every newsletter contained an article (pre-approved by the team) on the pollution prevention project.

The General Manager was responsible for making presentations to senior managers at appropriate points in the planning exercise. The communication points were: the project initiation and establishment, the preliminary assessment and prioritization of waste sources, recommendations on particular pollution prevention options, implementation of the desired solution and at various times to report progress.

It was also agreed that waste generation quantities would be posted on the employee notice boards in the plant for each of the plant operating units along side the Environmental Policy Statement and objectives of the pollution prevention planning project.

Example 3. Peerless Communication Plan

SUMMARY

The Pollution Prevention team is established and begins to meet. The team develops an Environmental Policy Statement, assigns roles and responsibilities for team members and sets objectives and priorities for the pollution prevention project.

STEP 2. CONDUCT PRELIMINARY ASSESSMENT OF WASTE SOURCES

Purpose	· To inventory all sources of waste
Objectives	· Inventory all wastes · Conduct self assessment using "Environmental Management Checklist" · Collect available in-house data and quantify waste sources · Complete mass balances of major chemicals in use in facility with available data · Identify information gaps
Products	· Assessment of environmental practices **(Example 4)** · Comprehensive list of waste sources **(Example 11)** · Block process diagram with material inputs and outputs **(Example 7)** · Material balances **(Example 8)** · Site inspection with list of observations **(Example 9)** and Best Management Practices (BMP) recommendations **(Example 12)** · Process flow diagram **(Example 10)** · Information on quantity and costs associated with wastes **(Example 11)**
Timing	· Effort: 1-5 person days for site inspection and collection of available in-house data · Duration: about 1 week, conducted at beginning of the program
Who	· Team, operating, technical and administrative staff, external resources
Roles	· Team conducts site inspection and data collection with support from staff familiar with information source. For external resources, the following may provide useful assistance to the process by offering a different perspective to the site inspection and waste source identification: ° Consultant - External observer ° Suppliers - limited role, however, valuable if supplier offers unbiased opinion on identification of **all** potential waste sources ° Industry Associations, Supplier Associations, Government - may provide role of Consultant

Tools

- Forms 3, 4, 5, 6 and 7 **(Appendix D)**
- Mass balance calculations **(Appendix B)**
- Flow schematics, sewer diagrams, plant layout, equipment manuals **(Company files)**
- Best Management Practices Plans **(Appendix H and I)**

INTRODUCTION

This step focuses on a preliminary audit of the facility to identify all waste sources and streams. The following tasks will be completed in this step:

- a self assessment of in-house environmental management systems
- a review of the facility layout and the production processes
- identification of inputs to the facility (raw materials, etc.,) and outputs (products, wastes, etc.,)
- a detailed site inspection to identify and quantify waste sources and streams
- preparation of a "complete" waste inventory.

The step is a cyclic activity of information sessions, site inspections, analysis and discussion to develop a waste inventory. First, in a Team information session, identify all aspects of the production and waste management systems. Follow the information session with a site inspection, analysis and discussion session. Finally, the Team should use their observation skills and unique insight to develop a "waste list" or inventory of wastes. Repeat the information session, site visit and analysis session until the inventory is complete. The information and analysis sessions should make use of the available in-house information and manuals such as: equipment and process operating manuals, bath chemistry recipes, MSDS data, purchasing records, waste manifest records and knowledgeable staff.

At this stage create or update a schematic process flow diagram of each production line to reflect the current operations. The diagram will provide insight into the waste generating processes. A sewer layout diagram should also be obtained or produced to identify the waste discharge locations and their receiving environments.

Form 3
Page D-6

Self Assessment of the Environmental Management Systems

As indicated above, the step consists of information sessions, site visits and analysis sessions. The first cycle should address the environmental management systems in place in the facility. This activity will introduce the Team to environmental management systems and help identify the regulatory requirements, environmental impacts, waste sources and quantities and acceptable waste collection and management practices. The eight page checklist, **Form 3, The**

Environmental Management Checklist, addresses the following areas/issues: health and safety, inventory management, packaging, storage, waste segregation, consolidation/ reuse/ recovery, preventive maintenance, spill response and operational practices. It takes about one to two hours to complete. ***Example 4 on page 25*** shows a sample of a completed self assessment Environmental Management Checklist.

*C) **Packaging Management***

C1. Are employees trained in ways to safely handle the types of drums & packages received? — *C1. **Yes** (Yes/No)*

C2. Are drums, packages, and containers inspected for damage before being accepted? — *C2. **4** (0-4)*

Describe handling procedures for damaged items:
Damaged items are placed in a holding area until suppliers are able to pick them up. Suppliers are contacted immediately.

C3. Are empty containers well rinsed so they can be recycled or handled as a nonhazardous solid waste? — *C3. **3** (0-4)*

*D) **Storage Management***

D1. Are personnel trained to ensure proper handling and storage of materials? — *D1. **Yes** (Yes/No)*

D2. Does the company use a first-in first-out material use policy to prevent materials from deteriorating in storage? — *D2. **2** (0-4)*

D3. Does the company minimize inventory to prevent material degradation due to prolonged storage? — *D3. **1** (0-4)*

Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

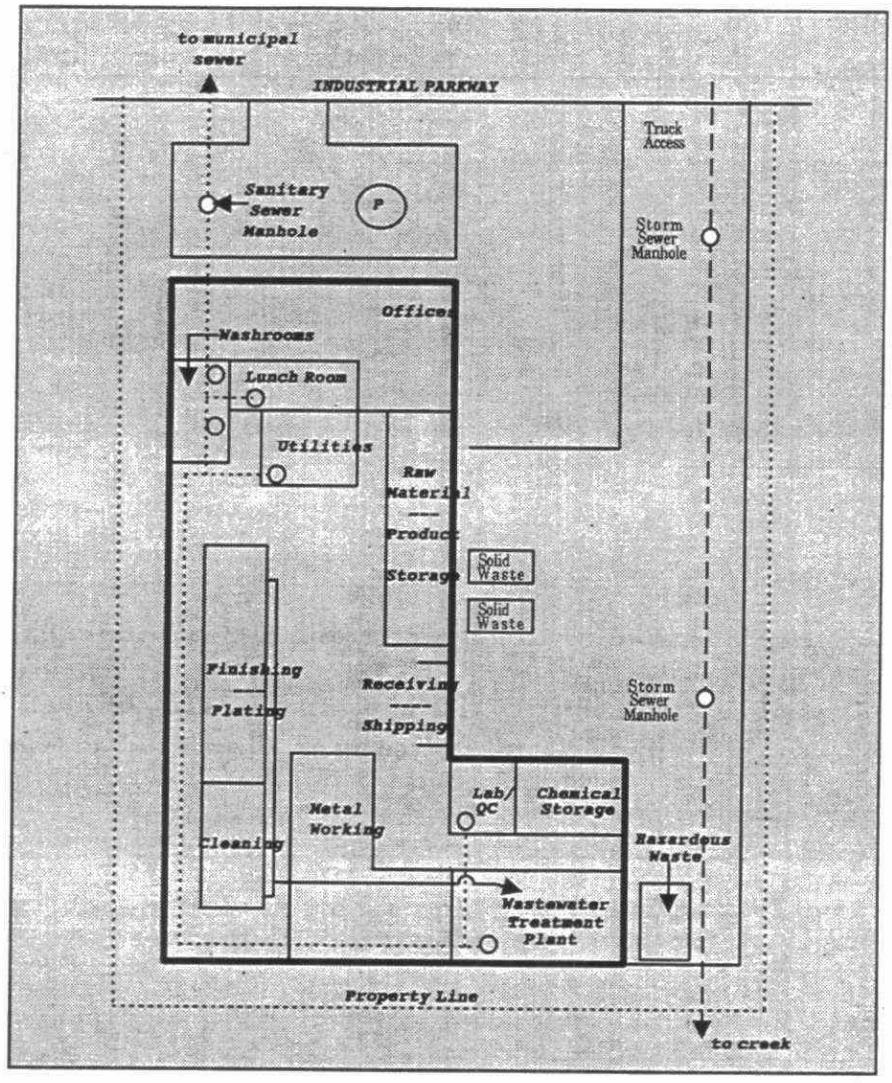
Example 4. Partially completed Section of an Environmental Management Checklist [Form 3 Appendix D]

Before conducting the self-assessment inspection, the Team should meet to review the checklist and complete all possible questions to the best of the Team's abilities. Following a tour, the Team should review, modify and complete the Checklist based on any additional knowledge and insights gained from the site inspection.

Members of the Peerless Plating Team completed the Environmental Checklist in two sessions prior to conducting their initial site inspection. Some questions could not be answered, and some of the suggested responses were disputed, requiring confirmation with the site tour. Following the tour through the facility, the team again reviewed their responses, correcting some and answering those previously left incomplete.

Plant Layout

The Team members must know the facility layout and production processes and other operations. Use a schematic facility layout, ***Example 5 on page 26***, from the company files or draw one later from



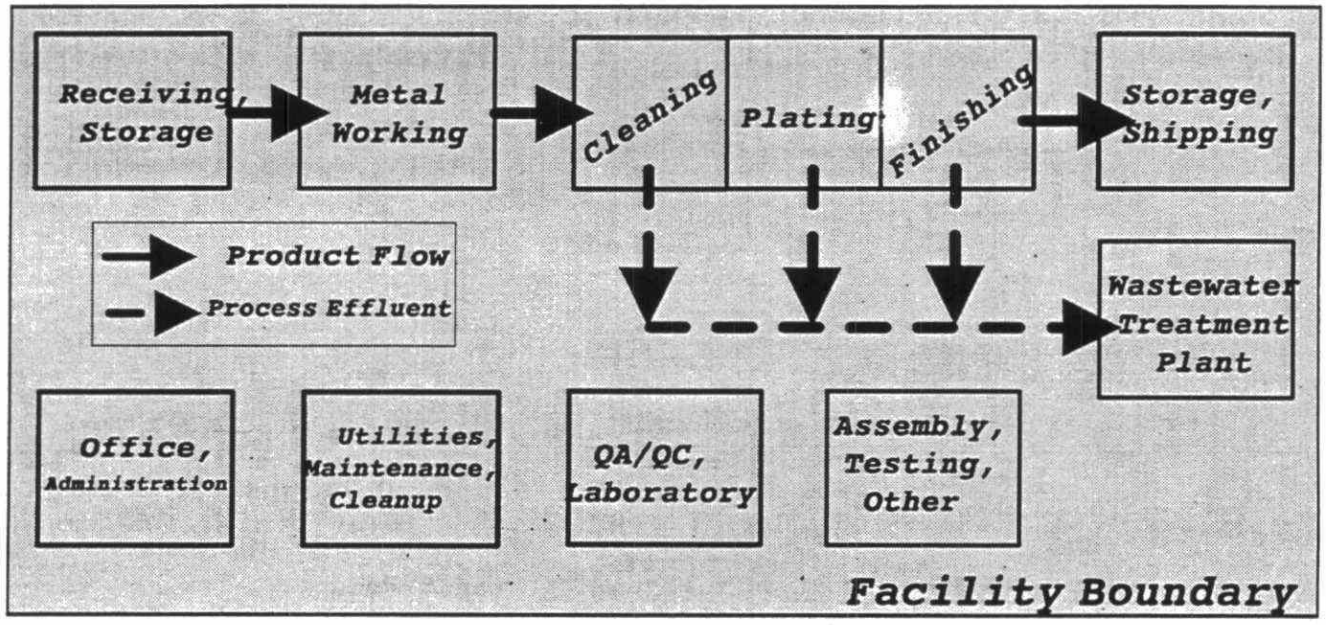
Example 5. Peerless Plating Plant Layout

the information collected during site inspections. It should show the location of all drains, service covers, sanitary and storm sewer lines, process or operating areas and building outlines. The sanitary sewer collects all sanitary and process wastes and conveys them to a municipal sewage treatment plant. Storm sewers collect the outfall from roof rainwater leaders and surface run off from the site. They convey storm water to a municipal collection system or to the nearest watercourse.

The schematic layout helps the Team better understand the facility and the interrelationship between production process areas. It also helps the team identify potential problem areas such as untreated waste leaks, spills or piped discharges into sanitary or storm sewers. The location of the key functional areas of the plant may affect decisions about how to approach improvements to operational practices.

Process Material Inputs and Outputs

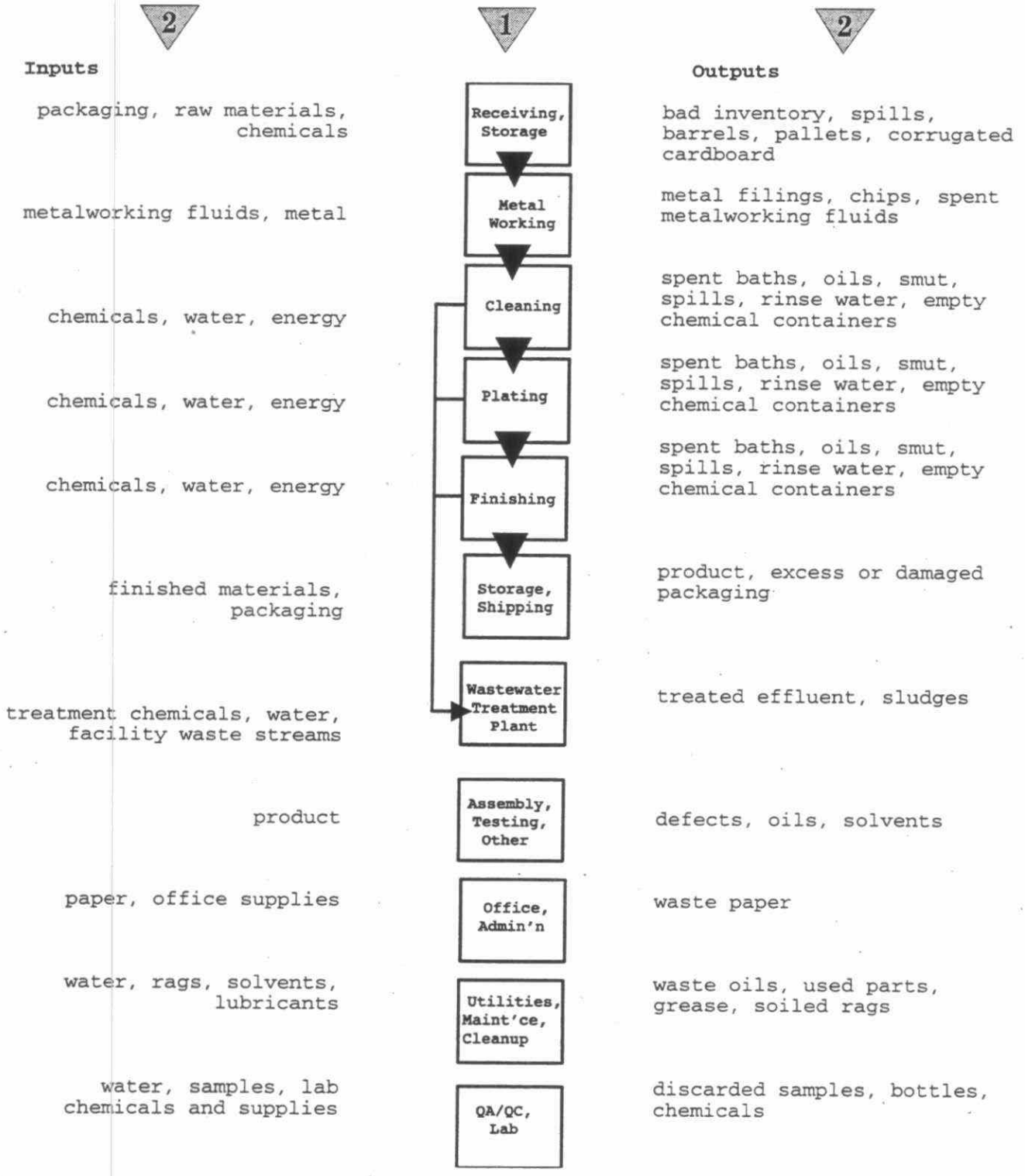
Using the schematic facility layout, process flow diagrams and information collected during the environmental management system self assessment, the Team creates a block diagram of the main facility areas. The diagram highlights the basic production areas and include the shipping, receiving, maintenance, laboratory and office areas. ***Example 6 on page 27*** shows a block diagram of the Peerless facility.



Example 6. Peerless Plating Block Diagram

Then, it is practical and useful to rearrange the blocks into a vertical format, as shown in ***Example 7 on page 28***. Using **Form 5, The Generic Process Diagram**, the production, shipping, receiving and waste management areas should be arranged sequentially with respect to material flow in a vertical column in the center of the Form.

Form 5
Page D-17



Example 7. Inputs and Outputs to Peerless Plating Operations [Form 5 Appendix D]

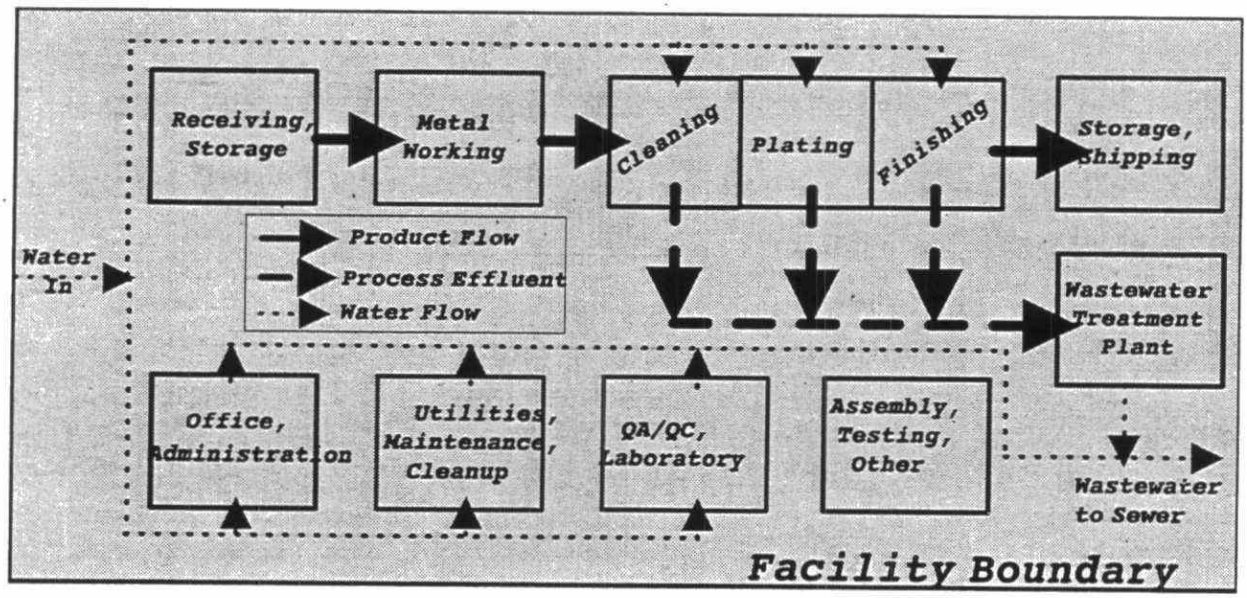
The non-production areas are placed below the production areas as shown under "Column 1" of Example 7. From available information, place the material inputs and outputs to each activity in vertical columns for each of the process area as shown under "Column 2" of Example 7. This will help the Team focus on wastes and their sources. Additional information on material inputs and outputs will be collected during the site inspection.

After completing the schematic layout and block diagrams of the facility, the Team then collects and examines all pertinent information on the facility. Collect information on the unit processes to document the materials used and produced by each process so that waste sources can be identified. Be as complete as possible. Typical sources of information may include:

- product specifications
- waste manifests
- waste water analyses
- MSDS data
- operations manual
- purchasing and shipping records
- water and sewer records
- energy bills
- laboratory records
- previous audits

In addition, Appendix E Chemical Use in the Metal Finishing Industry, should be examined. It lists chemical use, regulatory requirements and hazardous conditions for many chemicals.

The Team should attempt to develop complete material and water balances for the facility. ***Example 8 on page 29*** shows a typical water balance around the Peerless facility.



Example 8. Peerless Plating Water Balance

The municipal water meter reading will provide information on total water into the facility. Online meters or controllers should provide water flows for each of unit process. It may not be possible to develop these material and water balances because information is missing. Note the missing information. It should be collected during the detailed site inspection or estimated from other information.

Detailed Site Inspection

This activity is a comprehensive systematic tour of the facility to collect information on all waste sources and streams. For each waste source or stream, record the location, observations and remedial action recommendations on **Form 4, The Site Inspection Form.** A section of the Site Inspection record for Peerless Plating is presented in ***Example 9 on page 30***. The following "Rules of Thumb" will help guide each Team member and assist them in identifying potential waste sources.

Form 4
Page D-15

SITE INSPECTION FORM - Peerless Plating

Tour Date: 03/25/93

Participants: Peter Smith (Plant Mgr.), Betty Murphy (Safety Officer), Paul Brown (Shift Foreman), Joe White (Line Operator), Bill Smith (Contractor)

1. LOCATION:

   Plating tank #4

   OBSERVATION:

   Drip trays were found to be sitting horizontal along the plating line.

   RECOMMENDATION:

   [Angle drip trays to allow drag-out solution to drain back into the process tank.]

2. LOCATION:

   Nickel plating bath #7

   OBSERVATION:

   Water hose in use filling nickel plating bath left unattended.

Example 9. Site Inspection for Peerless Plating [Form 4 Appendix D]

The "Rules of Thumb" for identifying waste management opportunities include:

- location and/or availability of segregated waste containers
- employee disposal of cigarette butts, coffee cups, pop cans, newspapers, etc
- corrosion, chemical stains and build up of salt on equipment, on floors and roof vents
- general housekeeping in facility.

The "Rules of Thumb" for identifying resource recovery opportunities include:

- creation of waste material that is inconsistent with what one would expect from the production process
- water that could be recycled or cascaded for secondary reuse equipment
- processes that can be shutdown during off hours to conserve water and energy
- water or steam lines that should be insulated to save energy
- processes that may be operated in a "too clean" mode.

During the inspection tour complete **Form 5, The Preliminary Generic Process Diagram**, by collecting information on the inputs and outputs of each unit operation and adding the information to the Form.

Use **Form 6, The Generic Process Flowsheet**, to consolidate the unit operations data into a process flow diagram and confirm that the existing process schematic is accurate for each production line ***(see Example 10 on page 32)***. Include all relevant facility operations and ensure that all team members understand the interrelationship between the production processes and sources of wastes.

Form 6
Page D-17

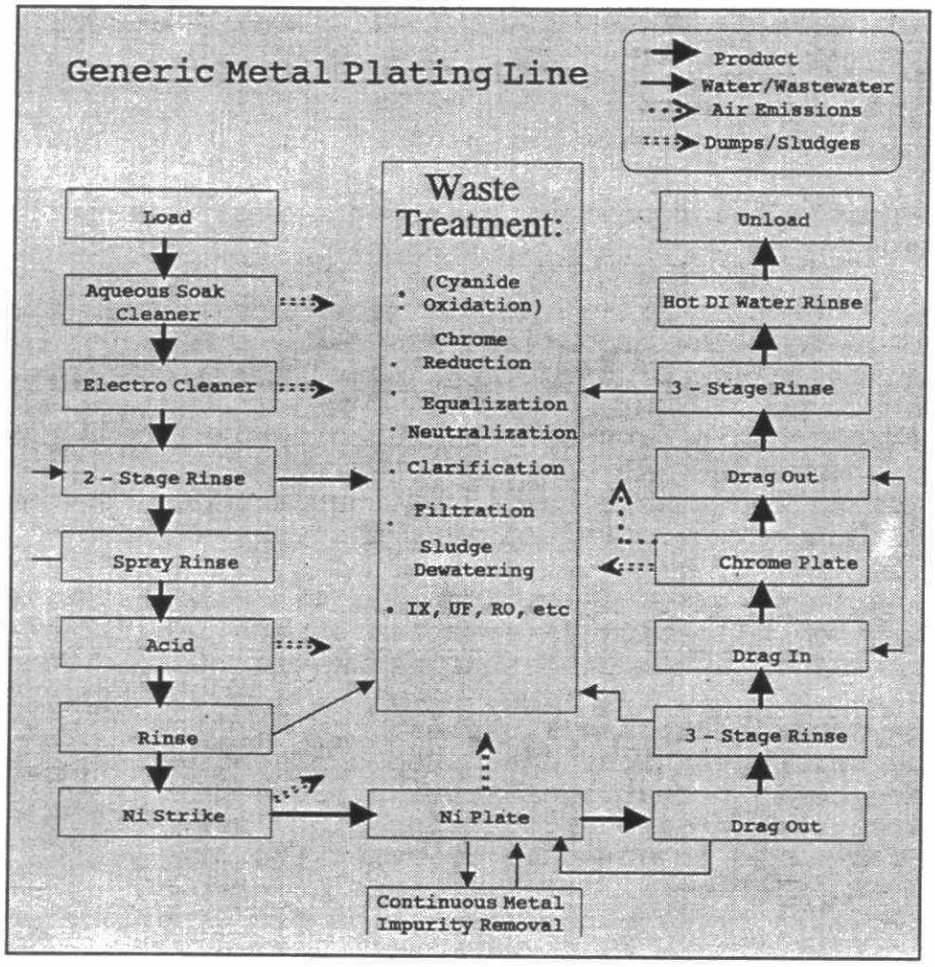
After the inspection tour, the Team should meet to review and consolidate the data collected on **Form 4, The Site Inspection Form**, **Form 5, The Generic Process Diagram**, and **Form 6, The Generic Process Flowsheet**. They should complete the following tasks:

- consolidate the observations and information collected **(Form 4)**
- review and discuss the observations and develop recommendations **(Form 4)**
- organize and finalize the material inputs and outputs **(Form 5)**
- organize and finalize the process flow diagram **(Form 6)**.

Identify additional in-house information that may be needed from:

- administration (Person Years, investments)
- purchasing (annual resource purchases)
- process areas (bath chemistries, manuals)

- laboratory staff (effluent, sludge data, analyses)
- the health & safety committee (WHMIS, MSDS)



Example 10. Peerless Process Flow Diagram [Form 6 Appendix D]

Team discussions about the information collected on the self assessment tour will assist in identifying all waste sources and streams. The Team should transfer the waste source or stream information to the "Waste Identification" column on the left side of **Form 7, The Waste Identification and Preliminary Assessment Form**. For each waste source or stream provide the following:

Form 7
Left Side
Page D-21

- a waste source or stream "ID #". The waste sources may be numbered consecutively from one to the total number of waste sources or streams

- the "FATE" of the waste source or stream (i.e., where does the

waste source or stream finally go). Five destinations are possible:

- the waste is returned to the process
- the waste is recycled on-site to another process
- the waste is recycled off-site for material recovery or reuse
- the waste is sent to a sanitary landfill site (waste classified as solid waste by MOEE Regulations)
- the waste is sent to a hazardous waste landfill site (waste classified as liquid industrial waste or hazardous waste by MOEE Regulations), or is discharged to a sanitary or storm sewer or surface waters or is stack or fugitive emission to the air.

- the "QUANTITY/YEAR" created or released in weight (lbs/year or kgs/year) or volume (gallons/year or liters/year)

The product at the end of the exercise is a list of possible waste sources as shown in the Peerless Plating inventory in ***Example 11 on page 34***.

BEST MANAGEMENT PRACTICES OR HOUSEKEEPING IMPROVEMENTS *(QUICK FIXES)*

Besides the inventory of wastes, some inefficient operating procedures, improper housekeeping practices and health and safety issues will be identified through the self assessment CHECKLIST and detailed site inspections. These may include improper stacking or storage of raw materials (i.e., materials stored in high traffic areas resulting in ruptured containers and spillage (or the risk of it)). Do the simple, inexpensive, quick fixes that are the low risk, low cost, obvious actions that also offer immediate cost savings ***(Example 12 on page 35)***. This will help to establish momentum in the program and encourage employee participation. It is important to show the reduction in waste results in dollars saved. Resolve housekeeping issues. Ensure elimination or reduction of wastes and do not transfer waste from one medium to another. Avoid turning water or air problems into solid waste concerns. Monitor progress and report successes: discuss throughout the facility, and get employee participation wherever possible (the participation of all employees will ensure an effective and successful Pollution Prevention Program).

SUMMARY

The products at the end of the Preliminary Assessment are:

(1) an assessment of the facility's environmental management system
(2) a list of material inputs and outputs
(3) a process block diagram
(4) a process flow diagram

(5) a comprehensive inventory of all wastes generated or released at the facility, along with information related to the "Fate" and "Quantity" of the wastes **(Form 7 Left Side)**
(6) a list of the BMPs or "Quick Fixes" that are required and that should receive immediate attention.

The next step in the program focuses on ranking the list of wastes on **Form 7, The Waste Identification and Preliminary Prioritization Form**.

Form 7 Left Side - Waste Identification			
PLANT AREA: Plating (General)		Fate (Where the waste is going)	Quantity/year Note units kg/y lb/y L/y gal/y
ID #	Waste Identification		
1	contaminated vinyl tape	sanitary landfill	80 kg/year
2	contaminated lead tape	recycle offsite for material recovery	200 kg/year
3	dropped parts		
4	alkaline cleaner bath spills	hazardous waste landfill	65 L/year
5	alkaline cleaner bath - sludges & dumps	hazardous waste landfill	650 kg/year
6	alkaline cleaner - rinsewater	sanitary sewer	400 L/year
7	sulphuric acid pickling - spills	hazardous waste landfill	35 L/year
8	sulphuric acid pickling - sludges & dumps	hazardous waste landfill	35 kg/year
9	sulphuric acid pickling - rinsewater	sanitary sewer	32 L/year
10	chrome bath - spills	hazardous waste landfill	430 L/year
11	chrome bath - sludges & dumps	hazardous waste landfill	140 kg/year
12	chrome bath - cleaning filters		
13	chrome bath rinse water	sanitary sewer	950 L/year
14	chrome bath air emissions	stack emission to air	180 kg/year

Example 11. Preliminary Inventory of Wastes at Peerless Plating [Form 7 - Left Side Appendix D]

Materials Inventory and Handling

- inventory system for raw materials
- new container inspection before acceptance
- first-in/first-out material utilization
- inventory protection from exposure to weather
- employee training: container handling, spill response
- minimize inventory by optimizing purchases
- minimize waste packaging by returnable containers
- dispose of obsolete material that cannot be returned

Spill Prevention and Control

- incident reporting, record keeping, follow-up prevention
- train employees in use of sorbents, neutralizing agents
- motivation of employees concerning spill prevention
- spill containment around high risk areas

Preventive Maintenance

- schedule inspections of equipment, systems
- appropriate adjustment, repair or replacement
- maintenance of records on equipment, systems

Housekeeping

- prompt removal/clean-up of small spillage
- regular garbage pick-up and disposal
- maintenance of clean and dry floors
- demarcation of proper pathways with no protrusions

Waste Segregation

- segregate hazardous from non-hazardous wastes
- look for reuse, recycle, reclaim opportunities
- segregate cyanide wastes from non-cyanide wastes
- segregate hexavelant chrome streams
- segregate chelate-containing and non-chelate wastes
- segregate streams requiring only neutralization

Source Reduction - miscellaneous

- keep solvent tanks covered when not in use
- remove dropped parts from tanks after every shift
- install drain boards between tanks to return drippage
- install flow regulators on rinse tanks
- shut off fresh water feed when plating line is down
- use warm water rinse after alkaline cleaning
- mix process baths by properly trained personnel

Example 12. Best Management Practices identified at Peerless Plating

STEP 3. PRIORITIZE WASTE SOURCES

Purpose	· To evaluate the inventory of wastes from Step 2 and to identify the most significant environmental concerns
Objectives	· To identify the primary criteria for assessing environmental concerns · To reduce the list of wastes to a short list of main concerns · Rank the main concerns in an order of priority to be dealt with
Products	· A short list of environmental concerns **(Example 13)** · A list of priorities for the company **(Examples 14 and 15)**
Time Frame:	· Effort: 3 person days · Duration:
Who:	· Team
Tools:	· Forms 7 and 8 **(Appendix D)** · Criteria Tables 3-1, 3-2, 3-3 and 3-4 · **Appendix E** · Brainstorming, Multi-voting **(Appendix B)**

INTRODUCTION

It is important to define WASTE, when trying to reduce or stop it. The following is proposed:

> "Waste is any material, used within an operation, which leaves the facility by any means other than as part of the finished product. The material will have a positive or negative value, either as the by-product or recyclable material value, or as a cost to treat, transport or dispose of it."

In this step the Team will review the long inventory of wastes developed in the previous Step and reduce it to a short list of wastes that can be addressed and resolved in subsequent steps. Prioritizing is a process whereby one looks at the various aspects of a waste such as quantity, cost of treatment or disposal, raw material cost, how hazardous or toxic it is, safety concerns, plus others, and with a numerical rating system leads one to a logical conclusion as to what to do first. Companies are encouraged to use the following two-step procedure:

1) The Team uses a set of criteria based on environmental concerns to reduce the long inventory of waste sources from Step 2 to a short list of waste sources.

2) The Team then uses a second set of criteria based on cost benefits and changeability to reduce and rank the short list of wastes to the final list.

The Right Side of **Form 7, The Waste Identification and Initial Prioritization Form**, is used to reduce the list by 80 to 90 percent. This step uses three environmental concern categories:

Form 7
Right Side
Page D-21

- "FATE" of the waste (where does the waste go). The five destinations were provided in Step 2.
- "QUANTITY" of waste (weight or volume per year)
- "TOXICITY RATING" of the waste (a measure of the hazard rating of the waste)

Using experience and past case studies, "Rating Values" were developed for ten levels of the "FATE" and "QUANTITY" environmental concern categories. Table 3-1 provides a recommended rating scheme for these two criteria. For each waste source

Fate	Quantity Liters/year Kilograms/year	Rating Value
Waste is returned to the process.	< 25	1
	25 - 50	2
Waste is recycled on the site to another process.	50 - 75	3
	75 - 100	4
Waste is recycled offsite for material recovery or reuse.	100 - 250	5
	250 - 500	6
	500 - 750	7
Waste is sent to a sanitary landfill (per MOEE Regulations.)	750 - 1000	8
	1000 - 5000	9
Waste is sent to a hazardous waste landfill site (per MOEE Regs.) or is discharged to a sanitary or storm sewer or surface waters, or is a stack or fugitive emission to the air.	> 5000	10

Table 3-1. Example Criteria Ratings for "FATE" and "QUANTITY".

listed on the left side of Form 7 in STEP 2, a Rating Value can now be assigned in the Fate and Quantity columns. These ratings can also be customized to suit your facility by using a Weighting Factor, which will be explained later.

The Toxicity Rating scheme for each waste source is provided in Appendix E. A section of Appendix E is provided below in Table 3-2. The Toxicity Rating is determined by:

1. identifying the components of the waste
2. locating the Toxicity Rating for each of the components from Appendix E, and selecting the highest value for use in Form 7

This Toxicity Rating value should be used as the rating for the waste regardless of the proportion of that component in the waste. The value is entered in the Toxicity Rating column.

Chemical Name	CAS #	NPRI Index	ARET Index	MOEE Index	ODS	Toxicity Rating
isopropanol	[67-63-0]	1				1
kerosene	[8008-20-6]					
lead + compounds	[7439-92-1]	1	4	8		13
magnesium salts	[7439-95-4]					
malic acid	[6915-15-7]					
manganese + compounds	[7439-96-5]	1		4		5
mercury + compounds	[7439-97-6]	1	4	10		15
methanol	[67-56-1]	1				1
methyl ethyl ketone	[78-93-3]	1				1
methyl isobutyl ketone	[108-10-1]	1	2			3
mineral acids		1				1
molybdenum + compounds	[7439-98-7]	1				1
naptha						
napthalene	[91-20-3]	1				1
nickel + compounds	[7440-02-0]		4	8		12
2-nitropropane	[79-46-9]	1				1

Toxicity Rating = ARET Index + MOEE Index + NPRI Index + ODS Index

Table 3-2. Example "Toxic Ratings" taken from Appendix E.

Table 3-2 shows the "Toxicity Rating" for some compounds typically found in the metal finishing industry. The "Rating" for each chemical was developed using their known, or suspected environmental

impact, as well as their presence on one or any of the following lists: NPRI List, Environment Canada ARET List, MOEE Bans and Phaseouts List and the Ozone Depleting Substance List (Appendix E).

If the Team decides to use Weighting Factors to address issues of concern within a specific plant such as environmental liability or volume reduction necessitated by space constraints, etc., then they should enter them as multipliers against these Fate, Quantity and Toxicity Ratings on Form 7. The identified value of Fate, Quantity or Toxicity becomes its listed value (from Appendix E) times the weighting factor (if used). Weighting factors should be used if the Team agrees to emphasize one or more of the factors.

Sum these final values of the Fate, Quantity, and Toxicity Ratings for each waste, and enter the value under Total Rating on the Right Side of Form 7. The Team should decide on the number of wastes to be tackled. They may decide to choose the top 10 or 15, or the top 10%, or if a group of common wastes can be handled with one solution. Another approach is to look for similar wastes that could be handled by a common pollution prevention technique.

ID #	Waste Identification	Fate	Quantity Rating	Toxicity Rating	Total Rating
	Plating (General)				
1	contaminated vinyl tape	8	4		12
2	contaminated lead tape	5	5	13	23
3	dropped parts				
	Chrome Plating Line				
4	Alkaline cleaner bath - spills	10	3		13
5	- sludges & dumps	10	7		17
6	- rinsewater	10	6		16
7	Acid Pickling - spills	10	2	1	13
8	- sludges & dumps	10	2	1	13
9	- rinsewater	10	2	1	13
10	Chrome bath - spills	10	6	13	29
11	- sludges	10	5	13	28
12	- bath cleaning filters	n/a			
13	- rinsewater	10	8	13	31
14	- air emissions	10	5	13	28

Example 13. Peerless Plating Example Ratings of Selected Waste Streams [Right Side Form 7 from Step 2]

The Peerless Plating staff developed an inventory of 300 wastes. The Team decided the wastes had to have a "Total Rating" value greater than 20 to be considered. The list was reduced to 38 main concerns by applying the initial prioritization step just discussed. The first 14 wastes of a total of 300 which were developed by Peerless Plating are presented in ***Example 13 on page 40***.

Your Team should reduce your initial list by 80 to 90 percent in this initial prioritization step.

In the Second prioritization or Short Listing Step, the Team uses Cost Benefit and Changeability criteria to further reduce and rank the list of wastes from the first prioritization step. The wastes chosen by the Team from Form 7 are transferred to the left side of **Form 8, Waste Source Prioritization -- Short Listing**. The purpose of Form 8 and the Short Listing Step is to help decide which top two or three wastes are going to be considered for further action.

The Cost Benefit category includes the following criteria:

- the health and safety concerns resulting from the waste
- the impacts resulting from the waste on receiving environment (air, water and land)
- the effect of the waste source on compliance with existing regulations
- the difficulty in controlling or managing the waste source
- the cost of the lost materials
- the cost to manage the created waste.

Using experience and past case studies, Rating Values were developed for ten levels of each criterion, as illustrated in Table 3-3.

The Changeability category includes the following criteria:

- the time to put a solution in place to reduce or eliminate the waste
- the waste reduction that may result from implementing the proposed solution
- the cost of implementing the solution
- the impact the solution will have on improving production.

Using experience and past case studies, Rating values were developed for ten levels of each criterion, as illustrated in Table 3-4 below.

If the Team decides to use Weighting Factors to address issues of concern within a specific plant, then they should enter them as multipliers against these Cost Benefit and Changeability Ratings on Form 8 just under criteria across the top of the Ratings. The identified value of any criteria becomes its listed value times the weighting factor (if used).

Health & Safety	Cost of Lost Material $000	Regulatory Compliance	Difficulty in Control	Environ -mental Impact	Current Cost to Manage Waste $000	Rating Values
No impact	< 1	no concern	very difficult	very low	< 1	1
	1 - 5				1 - 10	2
minimum impact	5 - 10	minor concern	difficult	low	10 - 20	3
	10 - 15				20 - 30	4
suspected health concern	15 - 20	moderate concern	minor difficulty	medium	30 - 40	5
	20 - 25				40 - 50	6
known health concern	25 - 30		easy		50 - 60	7
	30 - 40	serious problem		high	60 - 80	8
suspected carcinogen	40 - 50				80 - 100	9
known carcinogen	> 50	critical problem	very easy	very high	> 100	10

Table 3-3. Example Ratings of Cost Benefit Criteria

Time to Reduce/Eliminate Waste months	Potential Pollution Reduction %	Cost of Change $ '000	Impact on Production	Rating Values
> 36	0 - 10	> 50	no impact	1
24 - 36	10 - 20	40 - 50		2
12 - 24	20 - 30	30 - 40		3
9 - 12	30 - 40	25 - 30		4
6 - 9	40 - 50	20 - 25	some impact	5
4 - 6	50 - 60	15 - 20		6
2 - 4	60 - 70	10 - 15		7
1 - 2	70 - 80	5 - 10		8
1 - 4	80 - 90	1 - 5		9
< 1	90 - 100	< 1	significant	10

Table 3-4. Example Ratings of Changeability Criteria

Weighting factors should only be used to emphasize one or more of the factors compared against the others. Alternatively the Team could decide to use one or two of the criteria in order to prioritize the wastes.

Form 8
Page D-22

Sum these final values of the Cost Benefit and Changeability Ratings for each waste, and enter the value under Total Rating on the Right Side of Form 8. The Team should decide on how many wastes are going to be tackled, when Form 8 has been completed. They may decide to choose the top 1 or 2, or if a group of common wastes that can be handled with one solution.

The Peerless Team decided to use health and safety, the cost of lost materials and the cost to manage the waste as their Cost Benefit criteria, rather than all of them. They decided to use all the Changeability criteria.

Fishbone diagrams, brainstorming, pareto charts, etc. (see Appendix B) prove useful in identifying the most important criteria, rating values and weighting factors for the wastes in your facility. Focus on the major criteria; do not spend too much time on the minor ones. Finally, the weighted ratings are summed up for each waste source at the right side of Form 8.

The second stage prioritization is shown in ***Examples 14 and 15 on pages 44 & 45***.

SUMMARY

The product from Step 3 is a list of the 1 or 2 main waste sources to be targeted for action. The remaining wastes in the long inventory of waste sources (ie. 300 wastes in the Peerless example) will be addressed in the future. The focus in the following steps will be these 1 or 2 targeted waste sources. When these concerns have been resolved and the desired results confirmed , the Team should revisit the original inventory with a view to act upon the next priorities. A note of caution -- be aware that other processes may have been added, altered or deleted since the original waste inventory was developed.

Step 3 - Waste Source Prioritization - Short Listing		Impact Criteria					
ID #		Worker Health & Safety Rating 1-10 (see Table 3-3)	Cost of Lost Raw Materials Rating 1-10 (see Table 3-3)	Current Cost to Manage Waste Rating 1-10 (see Table 3-3)	Regulatory Compliance Rating 1-10 (see Table 3-3)	Difficulty in Control Rating 1-10 (see Table 3-3)	Environmental Impact Rating 1-10 (see Table 3-3)
	Weighting: 1= low; 2= med; 3= high	3	2	2			
	Waste Identification	Rating					
10	Chrome bath - spills	5	2	3			
		15	4	6			
11	Chrome bath - sludges & dumps	5	2	3			
		15	4	6			
13	Chrome bath - rinse water	5	2	4			
		15	4	8			

Example 14. Prioritization of Waste Sources - "IMPACT" Criteria [Left Side Form 8 Appendix D]

Step 3 - Waste Source Prioritization - Short Listing		Changeability Criteria				
ID #		Time to Reduce/ Eliminate Waste Rating 1-10 (see Table 3-4)	Potential Pollution Reduction Rating 1-10 (see Table 3-4)	Cost of Change Rating 1-10 (see Table 3-4)	Impact on Production Rating 1-10 (see Table 3-4)	TOTAL of IMPACT and CHANGE-ABILITY
	Weighting: 1= low; 2= med; 3= high	1	2	2	3	
	Waste Identification					
10	Chrome bath - spills	3	4	4	4	
		3	8	8	12	56
11	Chrome bath - sludges & dumps	1	1	1	4	
		1	2	2	12	42
13	Chrome bath - rinse water	2	4	3	3	
		2	8	6	9	52

Example 15. Prioritization of Waste Sources - Changeability Criteria [Right Side Form 8 Appendix D]

STEP 4. DETERMINE ROOT CAUSES OF SELECTED WASTE SOURCES

Purpose	· To determine the root causes of each priority waste stream
Objectives	· To select the most significant root causes and prioritize them for action
Products	· A list of major causes for each waste source selected in step 3 **(Example 17)** · Cause/ Effect Analysis Chart for each waste source **(Example 16)**
Timing	· Effort: 1-5 person days per waste source · Duration: about 1 month per waste source
Who	· Champion; Team; Operating or technical staff; External resources
Roles	· Team responsible for identifying potential cause of waste sources and may ask others to assist in this analysis ° Consultant - External facilitator ° Suppliers - assistance in root causes, ensuring that the supplier offers suggestions about possible causes and does not offer solutions to the problems at this stage. ° Industry Associations, Supplier Associations, Government - may provide role of Consultant
Tools	· Forms 9, 10, 11, 12 and 13 **(Appendix D)** · Brainstorming, Fishbone diagrams, Pareto charts, Multi-voting **(Appendix B)**

INTRODUCTION

In this step the team examines the potential causes of each waste source identified in step 3. It will be necessary to consider all potential root causes for each waste source and to determine which are most significant.

Step 4 requires a Cause/ Effect analysis which includes the following activities:

- Defining the problem [effect]
- Identifying possible root causes
- Selecting the most likely causes

Detailed descriptions of the tools and processes used in Step 4,

including instructions on TQEM procedures (brainstorming, fishbones, pareto charts, multi-voting, etc) are provided in Appendix B.

DEFINING THE PROBLEM

Each prioritized waste stream of concern in Step 3 is defined as a separate problem to be resolved. The original Team can look at each waste source or new Teams can be struck to examine particular wastes. Team members meet to better define the problem and identify other employees or persons that may assist in solving the problem.

It is essential that all Team members clearly understand the problem so that everyone can contribute to the identification of causes. It is important to avoid expressing the problem as a symptom. The Team should then undertake a cause/effect analysis of each waste.

IDENTIFYING THE ROOT CAUSE - CAUSE & EFFECT ANALYSIS

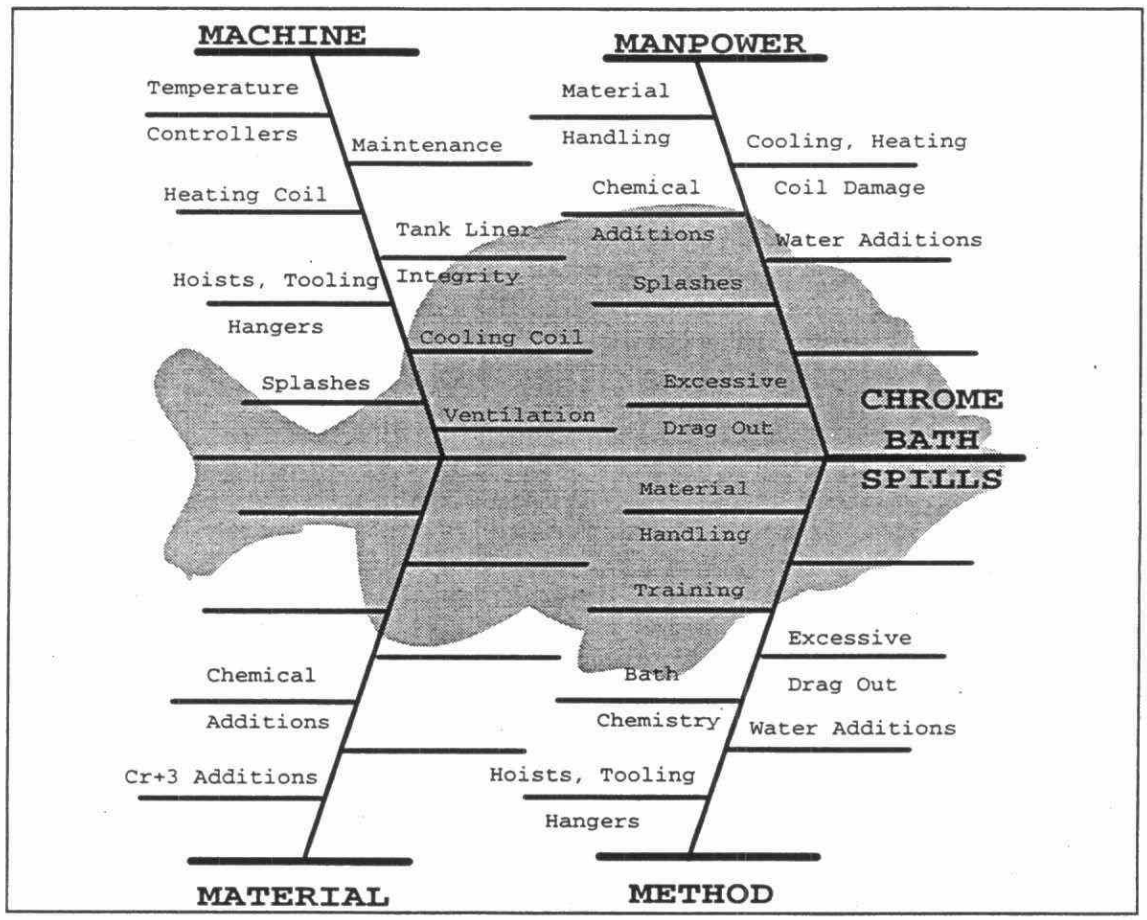
The cause and effect analysis allows the team to clarify the problem, identify and categorize possible causes, and select the most likely causes of the problem. The "EFFECT" is the waste while the "CAUSES" are any of a number of activities or conditions contributing to the generation of that waste. The "FISHBONE" diagram was developed as a method of mapping a list of causes contributing to a problem. **Form 9, The Options/ Concerns Analysis Chart**, an example of a fishbone diagram, is used by the Team to identify potential root causes of each waste.

Form 9
Page D-23

Most causes will fall under one of the following headings: **Methods**, **Machines**, **Materials**, and **Manpower**. These headings are used in Form 9, but may be changed to suit the specific waste problem being investigated. This activity involves brainstorming by the team members. All participants are encouraged to offer suggestions of possible causes of the problem. Each suggested cause is allocated to one of the four major headings (Methods, Machines, Manpower, Materials) and recorded on Form 9. ***(Example 16 on page 49)***

At Peerless Plating, chrome bath spills were determined to be a major problem. The Peerless Plating Pollution Prevention Team invited production staff and the plating shift foreman to a meeting to discuss the problem with them. In addition, Allkleen Chemical Company sent a technical representative to assist in the problem analysis.

The following fishbone diagram was generated. It was noted that some common causes were identified under each group. All ideas were included on the diagram and everyone at the meeting offered suggestions.



Example 16. Fishbone Diagram [Form 9 Appendix D]

Some suggested causes will be related to others. If this occurs, Team members should strive to identify the underlying root cause(s). A useful technique in doing this is asking the question ***"Why?"*** several times. For example, if leaking pumps were judged to be the most significant waste problem at a facility, and broken pump seals were identified as the likely cause, the obvious solution would be to replace the broken seals with new ones. This is what is defined as a "band-aid" solution which will never resolve the problem since the actual root cause was not identified. If the Team used the ***"Why?"*** technique the actual root cause would have been identified and the problem would have been eliminated.

The type of questions which should have been asked are as follows:

Q: "Why did the seals break?" ***A: There was too much friction inside the pump.***

Q: "Why was there so much friction?" ***A: Pumps were not properly lubricated.***

Q: **"Why were the pumps not properly lubricated?"** ***A: Nobody delegated to maintain pumps.***

Q: **"Why wasn't anyone delegated to maintain them?"** ***A: No preventive maintenance program.***

As you can see from the above example, asking ***"Why?"*** several times enables the team to thoroughly investigate the problem. Otherwise the primary root cause, ie. the lack of a preventive maintenance program, may not have been identified. Likewise, the best solution to the problem (implementing a preventive maintenance program) would have been overlooked ***(see Example 16 on page 49)***.

SELECTING THE MOST LIKELY CAUSES

After all possible causes have been listed on the Fishbone diagram, the Team must select the most significant root causes of the waste. Using best professional judgement, Team members evaluate the significance of each cause. This is called the Pareto Principle. Often, about 80% of most problems result from 20% of the causes. Many causes play a minor role towards the generation of the waste and the Team must eliminate these in order to focus on the development of solutions in the next step.

Company staff knowledgeable about the production processes associated with the waste must be consulted. The judgement and experience of this staff will prove invaluable. In addition, advice and external support from equipment and chemical suppliers or expert consultants and industry associations may also prove useful. It may be beneficial for the Team to revisit the particular area of interest to watch the operation in progress, and in this way each Team member will have a better feel for the role that an identified cause has on the problem.

Form 10, The Cause/Effect Analysis Table, will be useful in organizing and evaluating the root causes previously identified. The possible root causes are transferred to this table under the suitable headings (i.e. Manpower, Machines, Material, Method) from the fishbone diagram.

Form 10
Page D-24

The Team will use brainstorming to assign each cause a rank or criteria score based on the perceived significance of the cause. The score for each cause is entered under Criteria score in Form 10. The rank or criteria score of the root causes is used to select 20 percent of the original list of root causes (i.e. only those causes with high scores are considered further). The other 80 percent is discarded.

Using a multi-voting technique, each Team member is asked to rank the top 20% of probable causes from highest impact to lowest impact. The ranks are tallied to prioritize the list for further examination in

the next step **(Example 17 on Page 52).**

At Peerless Plating, the following Cause/Effect Analysis table was completed. To assist in quantifying each root cause, the effect "Mass of chromium lost per year" was selected. Through discussion with team members and advice from the knowledgeable members, each potential root cause was given a score from 1 to 5 by the team as a group, based on the estimated or known relative annual loss of chromium. The list of potential causes was then pared down to 20% of the total list based on this score.

Team members were then requested to individually select and rank the 6 most likely primary root causes, giving what each believed to be the most significant cause a score of six, with the next most significant cause scoring a five, etc. Summing the scoring of each team member for each cause resulted in the identification of a prioritized list of the six most probable root causes (represented by the shaded areas in the following table), of chrome bath spills.

VERIFY MOST LIKELY CAUSES

When the costs of addressing the identified causes is large and the risk is great, it may be necessary to verify the causes using a brainstorming and multi-voting techniques. In these cases the Team should verify the magnitude of the waste source as outlined in the detailed information section below. If the Team is comfortable with the prioritization results and believe that the most significant causes have been identified, this step will not be necessary. In most cases the solution to the waste cause will require background information to assess them properly and detailed information collection might be necessary for the economic analyses in Step 5.

Verification of a cause involves conducting a test or collecting additional data to quantify the contribution to the waste source. Verifying data may be a simple task of monitoring and recording incidents such as pump leaks, spills or overflowing tanks. Or the task may require that a detailed sampling program to collect data for a cost analysis of the waste causes be conducted.

Item No.	Category	Description	Criteria[1] Score 5=high 1=low	Multi-Vote (6 votes/member)					
				A	B	C	D	E	Tot
1	Manpower	Water additions	5	6	6	6	6	6	30
2		Parts handling	1						
3		Splashes	1						
4		Coil Damage	3						
5		Excess drag out	3+	4	2	5	1	2	14
6	Material	Chemical additions	1						
7	Method	Rinsing process	2+						
8		Tooling/Racking	1						
9		Training	2						
10		Bath chemistry	2						
11	Equipment	Tank liner integrity	3						
12		Temperature controls	4	1	1	1	3	4	9
13		Pump & filter leaks	4+	2	3	3	5	5	18
14		Filter disposal	2						
15		Rack failures	1						
16		Ventilation (up)	2						
17		Vent leaks	4	5	4	2	4	3	18
18		Maintenance losses	2						
19		C^{+3} dummying	4	3	5	4	2	1	15

1. Criteria selected was mass of chromium lost annually.

Example 17. Peerless Plating Cause/Effect Analysis Concern: Chrome Bath Spills [Form 10 Appendix D]

DETAILED INFORMATION COLLECTION

In the detailed information collection phase, collect detailed information only when necessary. The objective is to collect sufficient information on the primary causes to:

(1) identify the nature, size and economic value/cost of the cause

(2) aid in the selection of pollution prevention actions.

Activities associated with this task are described in the following.

- Develop a sampling/monitoring program

Develop a program and a schedule to ensure that the necessary information is collected to verify the significance of the waste cause. Gather information specific to the root cause identified only.

- Examine the contributing waste generating processes individually (i.e. in the example, waste causes 1, 5, 12, 13, 17 and 19 were selected as the primary causes of chrome bath spills)

A separate flow diagram for each process allows for more detail, however, the link between process streams should be kept in mind.

Form 11
Page D-25

- Identify operation material flows

- Quantify operation material flows

Utilize existing records if available and measure directly where possible. Evaporative emissions may be estimated from records of make-up liquid requirements.

- Identify priority operation(s)

- Identify key characteristics of unit operations. **Form 11, the Detailed Data Collection Form** may be useful for plating and cleaning operations

This will identify the key characteristics that control the performance of the operation which will clarify what improvements can be made.

- Quantify unit material flows

The make-up rate and dumping frequency should be available from records. Evaporation, drag-in and drag-out rates may have to be estimated.

- Collect additional data (as required)

- Address multi-media monitoring

The possible impact of current actions on other processes should be recognized and monitored.

- Conduct "Material Balance" about unit operation(s)

[mass input] = [mass on product] + [mass in sludge] + [mass in waste water] + [mass in emissions] + [unaccountable losses]

Specify each equation component in terms of process flows. Track down unaccountable losses where possible. Complete **Form 12, The Material Balance Table(s)**, as appropriate ***(Example 18 on page 54)***.

Form 12
Page D-27

TIME FRAME: 1 year								
material	mass input	mass on product	mass in sludge	mass in wastewater	mass in emission	total wastes	total mass output	unaccounted-for losses
	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]
Cr	8000	5700	680	85	6	771	6,471	1,529

Example 18. Material Balance Table [Form 12 Appendix D]

Note: It may be difficult to quantify certain metal pathways, especially the mass of metal plated on parts and/or the mass lost to emissions. For these pathways, *"best approximations"* may be used based on existing data. Otherwise the particular pathway should be grouped with "unaccounted-for losses".

A poor unit balance may indicate a missing flow or bad measurement within a different unit.

- Summarize waste source information for the waste stream(s) being examined

Using the information collected in Step 2 and 4, summarize the waste source information and identify any missing data. The Summary of Potential Waste Sources Form may be of use.

Form 13
Page D-28

After all of the necessary detailed data has been collected, the primary causes for the priority waste concerns should be identified, verified and quantified. This information is important for the next stage of the process (STEP #5 Generate,

Assess, and Recommend Pollution Prevention Actions) in which cost-effective resolutions based on economical, technical, and environmental analyses will be investigated.

SUMMARY

In this step the team worked together to generate a prioritized list of the most probable and significant causes of a waste. In the next step options will be identified to deal with these probable causes.

STEP 5. GENERATE, ASSESS AND RECOMMEND POLLUTION PREVENTION ACTIONS

Purpose	· To select and recommend pollution prevention actions
Objectives	· Identify potential solutions for addressing probable cause(s) of identified wastes from step 4 · Collect necessary data to assist in developing pollution prevention actions · Cost/benefit analysis on actions
Products	· Data on processes and pollution prevention technologies · List of potential solutions for each probable cause **(Example 19)** · Economic feasibility and cost benefit analysis on potential solutions **(Example 20)**
Time Frame	· Effort: 5 - 10 days for each probable cause for each waste stream · Duration: 4 - 6 weeks for each priority waste stream · Dependent on the complexity of the causes and solutions
Who	· Team · Company Staff including Management, Technical and Accounting · External Resources ie. - equipment and chemical suppliers, consultants
Roles	· Consultant can act as a process facilitator and /or can provide project assistance. · Supplier can provide technical information on processes and equipment · In addition, suppliers can assist in cost analysis as well as provide reference sites. · Industry associations, supplier associations and Government agencies can provide additional resource and reference materials
Tools	· Brainstorming **(Appendix B)** · Multi voting **(Appendix B)** · Weighting **(Appendix B)** · Forms 14, 15 and 16 **(Appendix D)**

INTRODUCTION

The purpose of this step is to: generate a comprehensive list of pollution prevention actions, perform a cost/benefit analyses and recommend actions for the elimination or reduction of the priority waste sources identified in step 3. To do this, the list of most significant causes for each waste stream (from step 4) are used to generate options for reducing or eliminating each waste stream.

Many actions are usually possible to deal with a given waste cause. In this step, the process to screen the options is described. This process helps eliminate marginal or impractical options, and identifies actions for immediate implementation.

During the process of selecting options, the environmental management hierarchy must be considered. Going down from the most desirable to the least desirable:

- source reduction (prevention)
- recycling and recovery
- treatment
- disposal.

It is important to look first for the pollution prevention alternatives involving source reduction/elimination and internal recycle/recovery. In the long run these are likely to generate solutions with the greatest benefits.

GENERATING ALTERNATIVE SOLUTIONS

In the previous step a list of significant causes for each of the priority waste streams (Form 10) was prepared. For each "major root cause", the generation of a list of potential solutions can be accomplished as follows.

Brainstorming

This technique works best in the initial stages of the alternatives generation process and for simple problems, it may be all that is necessary.

In brainstorming, the team, lists all ideas/ actions regarding the problem under review. In this case, the problem is the elimination or reduction of the impact of a cause of a particular waste stream. This step must be objective and free of criticism or judgemental behaviour. Team members are asked to present all ideas for solving the problem. The cause or problem under review must be clearly defined (eg. Over-filling of tanks is a major cause of chromium spills).

When the problem is more complicated (e.g. minimization of the rinse water make-up), this brainstorming exercise might be used to identify

possible sources of additional information such as suppliers and/or consultants. In these cases it is often necessary to collect additional data to better define the problem. Collecting additional data will also be necessary when the solutions being considered are time consuming, disruptive, expensive and/or require a major change in operation. In these cases the team will want to make sure that the changes finally selected and recommended will result in a significant reduction in waste and/or cost savings or other benefit (see verify most likely causes in Step 4).

Suppliers

Problems can be referred to various suppliers (equipment, chemical and process) for assistance. This is particularly useful as it usually produces data which will be valuable in the "Evaluation of Alternatives" stage.

Consultants

Consultants can be an additional source of potential solutions Other metal finishers who may have had similar problems can be consulted. This can, in many cases, shorten the "Evaluation / Screening" process. After the generation of ideas / solutions from the various sources has been exhausted, the next stage is "Screening".

EVALUATING SOLUTIONS

Once a list of possible solutions is generated it will be necessary to identify those ideas / solutions that can result in the most benefits for the lowest cost. During this process, a number of scenarios can emerge:

- impractical ideas
- ideas needing more detailed information and study
- ideas which can be implemented with minimum effort and cost
- a condensed list of ideas for further consideration.

The Team decides on the criteria to be used to select the best option. Generally it is necessary to pare the number of possible solutions to 20% of the original (i.e. if ten solutions were listed two solutions are examined further). These are then examined in more detail and the benefits evaluated.

Screening Criteria

The Team , using brainstorming and the multi-voting techniques, select a number of criteria on which to judge the options. Generally, the more complicated the problem, the more information that should be collected for solution definition and comparison. The following is a minimum list of criteria that should be considered by the team:

(1) What benefits are gained?

- waste minimization (volume, hazard potential)
- effect on health and safety.
- effect on product quality
- effect on productivity, process, compatibility.
- cost and cost savings.

Form 14
Page H-29

(2) Does the necessary technology exist?

(3) How long will it take to implement?

(4) Is there evidence that the solution / idea will work?

The Team should generate other criteria that is important to the company or facility as necessary. Criteria may also be assigned a weighting factor dependent on the team's feeling on the criteria's relative importance. The selected criteria and weighting should be put into the appropriate boxes on Form 14.

Prioritization

The Team uses a weighted criteria approach to list the possible solutions for further study, examination and consideration. A prioritization approach that works in metal finishing facilities uses the following criteria for rating options:

- waste reduction potential
- worker health and safety impacts
- impact on product quality
- capital equipment cost
- labour requirements (implementation, operation and engineering)
- utility requirements
- effect on productivity
- cost savings potential
- product/process compatibility
- physical space requirements
- availability of technology
- simplicity of technology.

Using experience and past case studies, "RATING" values were assigned for five levels of each criteria. Table 5-1 provides the rating scheme for the criteria with "RATING" values assigned to criteria levels.

Form 14 provides a method for performing the prioritization. The options are listed on the left hand side of the table in any order. The Team as a group will rate each option against the criteria.

Criteria[1]												Rating
Waste Reduction Potential	Worker Health & Safety	Impact on Product Quality	Capital Equipment Cost	Labour Require-ments	Utility Require-ments	Effect on Product -ivity	Cost Savings Potential	Product Process Compat-ibility	Physical Space Require-ments	Availability of Technology	Simplicity of Technology	
very low	very high impact	high -'ve impact	very high	very high	very high	very high	very low	incompatible	excessive	not available	complex	1[2]
low	high impact	some -'ve impact	high	high	high	high	low			concept		2
medium	medium impact	no impact	moderate	medium	medium	medium	medium	medium compatibility	medium	R&D	medium	3
high	low impact	some +'ve impact	low	low	low	low	high			proto-type		4
very high	very low impact	improves product	very low	very low	very low	very low	very high	very compatible	minimum	proven	very simple	5[3]

Table 5-1. Criteria and Ratings for Prioritizing Options

[1] **Premise is to bias <u>best case situation; namely favour easiest, least expensive solution</u>**
[2] **Rating of "1" represents least influence on selection**
[3] **Rating of "5" represents most influence on selection**

For example, if the team is looking at a degreasing operation and one of the options involves changing the solvent from a freon to another chlorinated compound; this option should receive a negative score against the health & safety criteria since the compound is more hazardous.

For each option and criteria: select the level of the criteria that best represents the impact, move across the Table and get the "RATING", enter the "RATING" in Form 14, sum the "RATINGS" to get the "TOTAL". Companies are encouraged to use this approach ***(see Example 19 on pages 63 and 64)***.

The results of the screening activity are used to provide options for technical and feasibility analyses. The options which involve simple procedural change can usually be implemented quickly with little or no further evaluation, see "Operating Procedures" in STEP 2. Options that involve little risk , for example no capital cost, no lost production time, small procedural changes, do not need to go through the option analysis step. High cost, high risk options must be studied further and compared to other options before the final implementation option selection is made.

At Peerless Plating a cause/effect analysis on the Chrome rinse water problem resulted in the identification of the primary cause of too much rinse water being used. A brainstorming session including some of the production and process people resulted in a list of options to reduce the amount of rinsewater including implementing counter current rinsing, spray rinsing, etc. The team developed a list of criteria to be used to prune down the list of options for further analysis. The team decided that all of the criteria were of equal importance and did not weight them. The following table summarizes their prioritization activity which resulted in 3 options being put forward for further consideration, namely counter current rinsing, conductivity control and ion exchange.

OPTION ANALYSIS

The options selected for further study undergo an option analysis involving a technical analysis and an economic evaluation.

Form 15
Page D-31

a) Technical Analysis

- Test process changes for effect
- Arrange to visit installations using proposed equipment (obtain assistance from suppliers)
- conduct bench or pilot scale tests.

	waste reduction potential	capital equipment cost	labour require-ments	cost savings potential	effect on product	effect on productivity	simplicity of technology	health & safety	
Weighting[Note 1]	3	2	2	2	3	3	1	3	**Total**
Waste Reduction Solution	**Rating** (include "+" or "-" as appropriate								
Operator stays at tank	5	1	5	1	3	1	3	1	
	15	2	10	2	9	3	3	3	47
level control	5	4	5	4	3	5	5	5	
	15	8	10	8	9	15	5	15	85
high level alarm	3	5	5	2	3	5	5	5	
	9	10	10	4	9	15	5	15	77
conductivity controller on coils	2	4	5	2	3	5	5	5	
	6	8	10	4	9	15	5	15	72
wash down feature	5	2	4	4	3	5	5	5	
	15	4	8	8	9	15	5	15	79
fume suppressants	5	5	4	4	3	5	3		
	15	10	8	8	9	15	3		68
drain boards	3	5	5	3	3	5	5		
	9	10	10	6	9	15	5		64

Note 1: Weighting - 1 = low; 2 = medium; 3 = high

Example 19. Prioritization of Pollution Prevention Options Waste Source: Chrome baths - spills & losses [Form 14 Appendix D]

	waste reduction potential	capital equipment cost	labour require-ments	cost savings potential	effect on product	effect on productivity	simplicity of technology	health & safety	
Weighting[Note 1]	3	2	2	2	3	3	1	3	**Total**
Waste Reduction Solution	**Rating** (include "+" or "-" as appropriate								
improve placement of exhaust vents	4	4	5	4	3	5	5		
	12	8	10	8	9	15	5		67
splash guards on tank	3	5	5	2	3	5	5		
	9	10	10	4	9	15	5		62
drip trays under tank	2	5	3	2	3	5	5		
	6	10	6	4	9	15	5		55
drip trays under external pump	2	5	3	2	3	5			
	6	10	6	4	9	15			50

Note 1: Weighting - 1 = low; 2 = medium; 3 = high

Example 19. Prioritization of Pollution Prevention Options Waste Source: Chrome baths - spills & losses [Form 14 Appendix D]

The technical evaluation of the option should include, as a minimum, answering the following questions.

- Are any new problems created? (transfer of one problem for another)
- Will product quality be maintained?
- How long will production be affected?
- What are the effects on Health and Safety?
- Is the new process and / or equipment compatible with operating procedures?
- What special expertise is required?
- Is adequate service from supplier available?

All functional groups which could be affected by the changes should be consulted and asked to review the options.

b) Economic Evaluation

Cost elements should be divided into two groups:

- Capital / Acquisition Cost

  Normally this incorporates the Purchase Price of the equipment plus any installation costs.

- Operation/Maintenance Cost

  - Energy, Labour
  - Supplies, and replacement parts
  - Maintenance Contract (if available).
  - Replacement Cost (amortized over life of equipment).
  - Decreased revenues from reduction in productivity (if this were to occur).

- The potential net savings or resulting costs from the pollution prevention action are measured.

  - Reduced waste costs (disposal and transportation)
  - Material cost savings (process material and waste treatment materials).
  - Reduced labour, energy and water costs.
  - Insurance and liability savings
  - Increased revenues from productivity and quality improvements.

Peerless Plating conducted the options analysis for chromium spills. It is provided in ***Example 20 on page 66***.

PROFITABILITY ANALYSIS

The net cash flow is determined (Savings minus Operating/ Maintenance Cost). If the cash flow is positive and there are no Capital

Waste Stream Identification: *Chromium spills*

Root Causes:
- *overfilling of tank with water*
- *exhaust system inefficient*
- *mechanical failures with pumps and hoses*

Pollution Prevention Option: *Install level controller*

Description: *A level controller will automatically sense when the solution will require water. This will activate a solenoid valve allowing addition of water. Once the level reaches the preset limit the water will shut off. This unit will allow the operator to attend to other duties and will prevent the accidental overfilling of tanks when hoses are left unattended.*

Is pilot testing required?: ~~Y~~/[N] **Describe:** *N/A*

Equipment (include: • availability, • reliability, • example applications)
Equipment is available. The vendor referred us to XYZ Plating. We spoke with XYZ company personnel and they are happy with the unit.

Special Considerations: *As there is the possibility of "gumming" up due to the nature of chromium solutions, we should not use a controller incorporating a float. Capacitive or resistance type probes on the controller should be used.*

Potential Vendor(s): Competitive bids: ~~Y~~/[N] Supplier support available: [Y]/~~N~~

ABC Equipment supplies the unit.

Equipment Cost: *$5,885.00 (Canadian) plus GST; FOB: Delivered*

Maintenance Requirements: *Simple routine check of probes and cleaning as required.*

Effect on product quality: *There is the potential of a positive benefit by maintaining the chromium solution closer to the customers recommended limits.*

Effects on production: *None. Additionally, no machine down time will be required to install the equipment.*

Estimated waste reduction level: *Chrome spills are currently estimated at 900 kg/a. These spills will be minimized, if not eliminated, thus significantly reducing losses of chrome into the environment.*

Estimated cost savings: *Estimated at $2500/a chemical purchases, which is the amount of chrome lost in the spills, plus $7500/a.*

Impact on employee health and safety: *Benefits will be realized, since operators will no longer need to be in close contact with the plating solution during fillings and/or spills clean ups.*

Submitted by: *Peter Smith* Date: *18 June 1994*

Example 20. Options Analysis for Peerless Plating - Chrome Spills

or Acquisition costs, the action should be immediately implemented. If there are Capital / Acquisition costs, the simplest way to determine feasibility is to calculate the Payback.

$$\text{Payback (in years)} = \frac{\text{Investment}}{\text{Net savings per year}}$$

Typically any action which provides less than a 2 year payback is a strong candidate for implementation. Where there are competing options, use of discounted cash flow techniques such as IRR (internal rate of return) and NPV (net present value) can prove to be useful. Most financial software programs are capable of computing IRR and NPV and accounting text books also cover these topics.

RISK AND LIABILITY ADJUSTMENT

Pollution prevention actions can reduce a company's environmental and safety risks as well as waste. While these risks can be identified, some pollution prevention options may not meet payback requirements when viewed strictly on a financial basis. In these cases, the decision maker must be aware of the liability and risk reductions. Some companies are establishing longer pay back requirements in these situations.

After the technical and economic assessments are completed we will generally have:

- Actions which can be immediately implemented as above (BMP's / Operating Practices)
- One option for each root cause for each waste stream to recommend to senior management for implementation
- Options which need further study (See Additional Study Below).

ADDITIONAL STUDIES

During the screening and assessment stages, there can emerge pollution prevention options which cannot be fully assessed due to the lack of information. If these options are regarded as serious candidates for implementation then further information should be sought. This may entail rerunning the characterization of root causes and/or waste streams and analysis of flow rates and the effluent, etc.

REPORTING TO SENIOR MANAGEMENT

After the generation and assessment procedure has been completed, usually one or two options will emerge which are technically and economically feasible. These should be reported to Management including relevant information such as:

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- Waste stream and root causes that can be reduced or eliminated

- Savings and costs (itemized)
- Payback
- Possible vendors (include vendor fact sheets)
- References who have implemented similar procedures
- Risk and liability reduction
- Improvement in quality and productivity.

A well written report which documents the team's recommendation for a pollution prevention implementation project and the benefits to be gained can avoid delays in obtaining management approval. **Form 16, The Pollution Prevention Capital Funds Request and Approval Form** can be used to obtain the necessary approval from management on the recommended solution ***(Example 21 page 69)***.

SUMMARY

In this step the team generated and selected solutions to address the primary causes of the priority waste streams identified in step 3. The team generated information on the economic and technical feasibility of the most promising solutions and on this basis made a recommendation to senior management. Approval in principle for the allocation of the capital funds for the project is then sought. Where approved, the team puts together a detailed implementation plan for the recommended solution.

PEERLESS PLATING

POLLUTION PREVENTION
CAPITAL FUNDS REQUEST AND APPROVAL

Division/Dept **Plating** Date of Submission **Sept 14/94**
Project Number **091494** Project Name **chromium spills**
Project Contact **waste treatment supervisor**

I) PROJECT BACKGROUND

Project Description (be concise) **Proposed that level controllers with high alarms be installed on our five chromium tanks.**

Technical Assessment **The controllers automatically add water to the tanks and prevent overfilling of tanks.**

Waste stream(s) affected **Effluent from plating tank and sludge generated.**

Input materials affected **Reduce purchases of chromic acid.**

Product(s) affected **No effect on products.**

Pollution Prevented (check one or more)		First Year Quantity Prevented
Air Pollution	_____	Tons _____
Water Pollution	___X___	Tons **1.8**
Wastewater	___X___	Gallons _____
Solid/Hazardous Waste	___X___	Tons **11.0**

II) PROPOSED EQUIPMENT

Description of equipment **Each tank would be equipped with a level controller connected to a solenoid on the water line and a high level alarm.**

Supplier **ABC Equipment**

Purchase Price **$ 5,885.00 plus GST FOB: delivered**

Installation Cost (if not included in Purchase Price) **$ 750.00**

Example 21. Peerless Plating Capital Funds Request [Form 16 Appendix D]

III) OPERATIONS IMPACT

Changes in production or product quality **No impact on production or product quality.**

Environmental impact **Would reduce amount of hexavelant chromium going to waste water treatment by 1,800 lbs/yr and reduce hazardous waste sludge by 11 tons/yr.**

Health and Safety **Would reduce worker exposure to concentrated hexavelant chromium solution which has to be pumped from sumps under tanks.**

Training Requirements **Supplier will provide training for approximately 1 hour to all shifts. Equipment is quite simple to operate and maintain.**

Is the recommended equipment required to bring operation into compliance (current or proposed legislation)? Explain.

No. Our effluent is in compliance. Equipment will reduce chemical purchases by $ 2,600/year and waste treatment and disposal by $ 7,500/year.

Will production be affected during installation? **No.**

Explain **We add water every 4 hours to tanks manually at moment. Installation only requires 2 hours per tank.**

Attach installation schedule, detailing all activities.

Example 21. Peerless Plating Capital Funds Request [Form 16 Appendix D]

IV) FINANCIAL IMPACT [indicate decreased by ( )]

Change in Disposal costs **($ 2,500/year)**

Change in Raw material costs **($ 2,500/year)**

Change in water costs **Not measurable.**

Change in electric costs **Not measurable.**

Operation and Maintenance costs **Not measurable.**

Other costs **wastewater treatment ($ 5,000/year)**

Net cost impact of implementation **+ $ 4,000 in year 1**

Estimated payback in Years **Approximately 6 months.**

V) PRODUCT APPROVALS

Project Team by **wastewater treatment supr.** Date: **Sept. 14/94**

Environmental by _____ Date: _____

Health and Safety by _____ Date: _____

Production by _____ Date: _____

Engineering by _____ Date: _____

Finance by _____ Date: _____
Division Manager _____ Date: _____
General Manager _____ Date: _____
President _____ Date: _____

If project is not approved, please provide explanation.

_____

_____

Example 21. Peerless Plating Capital Funds Request [Form 16 Appendix D]

VI) PROJECT FOLLOW UP

Installation completed on _____

Results to date:

* Costs _____
* Environmental _____
* Production _____
* Quality _____

Publicity releases completed:

* Customers _____
* Trade associations _____
* Government _____
* Community _____

Further Action _____

_____

_____

_____

Example 21. Peerless Plating Capital Funds Request [Form 16 Appendix D]

STEP 6 IMPLEMENT AND MEASURE SOLUTIONS

Purpose	· To implement pollution prevention option(s), monitor progress and measure success.
Objectives	· Prepare detailed implementation plan · Prepare detailed cost estimate · Inform employees of pollution prevention project · Install the pollution prevention solution
Products/Outputs	· Reduction or elimination of waste · Cost reductions and product improvements · An informed and enthusiastic workforce
Time Frame:	· Depends on the project scope
Who:	· Champion; Operating Staff; Accounting Staff; Equipment and chemical suppliers; Management
Roles:	· Consultant (assistance in implementing changes) · Industry & Supplier Associations (no role) · Suppliers (significant role as technical advisor) · Government (possible funding partner)
Tools:	· Total cost accounting package · Change-management techniques · Measurement/ monitoring techniques **(Appendix B)** · Sampling methodologies **(Appendix B)**

INTRODUCTION

Once the solutions have been selected, prioritized, recommended to management and approved, the Team must develop a program to incorporate them into the daily operations of the plant. While the projects may have been approved in principle it is at this stage that final approval and allocation of funds is obtained.

It is also important to keep the rest of the company informed about the changes. Plans vary in complexity with the magnitude of the task. Simple housekeeping problems such as segregation of wastes are not as complicated as implementing a plan involving the replacement of a piece of processing equipment.

IMPLEMENTATION PLAN

Before implementing solutions, it is usually necessary to prepare detailed engineering, costing and specification plans. A technical

Implementation Plan along with analysis for minimizing the impact on existing operations must be prepared to ensure that the options are incorporated correctly and in a timely manner. Suppliers can arrange reference contacts, visits to other plants that have already carried out this change and can offer valuable advice and suggestions regarding the formulation of the implementation plan. The plan should include schedules for site preparation, construction, removal of old equipment, equipment purchasing, equipment installation and start-up, performance evaluation testing, operator training and other relevant steps as required by the particular project. The Implementation Plan should also include human resource assignments, roles and responsibilities and should clearly outline who has accountability for each task in the project.

Another way to view the Implementation Plan is that it is the Action Plan or schedule of activities which must take place in order to implement a pollution prevention action.

In any Implementation Plan the following must be addressed:

- A list of activities to be completed.
- The sequence of activities must be clearly identified.
- The length of time it will take to accomplish an activity must be identified. These estimates should be based on a best case situation and a worst case scenario.
- The individual(s) responsible for the various activities must be identified.
- If any activities will affect other departments, arrangements must be made to notify them.
- Will production be affected? If so and if it will be for an extended period, have contingencies been made by either notifying customers that the plant will be shut down, or alternatively, have arrangements been made to build inventory.
- A contingency plan should be in place to address the situations if something is delayed, or something goes wrong.
- With larger projects it is always wise to create a planning chart so that all the activities and their status can be easily reviewed.

With reference to planning charts there are a number of techniques which are commonly used, but we will confine ourselves to one of the easier ones to work with, which is Gantt charting ***(See Example on page 77)***. For information on other techniques such as PERT (Program evaluation and review techniques) or CPM (Critical Path Method) charting, refer to **Production and Operations Management** (2nd Edition) by J. Heizer and B. Render, Published by Allyn and Bacon.

In Step 5, we identified that the installation of level controllers represented a significant Pollution Prevention opportunity. A typical Implementation Plan would be as follows:

LEVEL CONTROLLER PROJECT PLAN

Primary Review

Supplier: ABC Supply Co.

Cost: $ 5,000

Delivery: 4 weeks from receipt of order.

Technical assessment performed: Yes

Have the necessary approvals been obtained?

Environmental:	Yes
Health and Safety:	Yes
Engineering:	Yes
Budget approved:	Yes

What is impact on production? There will be no impact on production; there are periods of idle time where no work is in the chromium tanks and the installation of the equipment can be coordinated with these idle periods.

NOTE: The above are the basic items which need to be addressed to ensure that nothing has been missed. It may be at this point that further investigation work is required before proceeding. We will however assume that the budget has been approved and all preliminary activities have been completed and we can now proceed with the actual plan.

Activities

1) Order equipment (order will be placed on Oct 20, 1994),
** This will be done by Purchasing.

2) Delivery of equipment (Equipment will be delivered on November 17, 1994)
** Purchasing will check on November 10, 1994 to be sure supplier is still on schedule. Purchasing will notify Project Coordinator of status.

3) Once equipment is on site, Mechanical Maintenance, and the Electrician will be notified.

4) Actual Installation

a) Mechanical Maintenance will install level probes on all chromium tanks. This can be done while parts are in the tank. This will take 45 minutes minimum per tank and a maximum of 1 and 1/2 hours per tank. There are three tanks which will have controllers installed.

b) When Tank A is empty, the water feed line will be turned off in order to install a solenoid in the line. This will be done by Mechanical Maintenance and will take 1 hour minimum and 1 and 1/2 hour maximum. Tanks B and C will be completed in a similar manner as they are emptied of production.

Notes: i) Once solenoids are installed, the water can be turned back on.
ii) It is unlikely that we will experience a water pressure drop which would activate the fire alarm at any time during the installation. As a precaution we should notify the fire department of our planned activities.

c) Simultaneous to (a) and (b), our Electrician will mount the controller and run the required wiring and conduits to the probes and solenoids. Timing is not critical as this activity will not impact any aspects of the operation.

d) Once Activities (a) through (c) are completed the Electrician will make the final connections to the probes and solenoids.

e) Activate system and check for any water leaks.

f) Deactivate system and notify supplier that installation is complete and arrange for employee training.

While the above is an example of a simple project we will now examine a major project. In this example we will only identify major project steps, but it should be noted that each project step could be broken down into a project itself, and thus have many components. We will conclude the example with a simple Gantt chart of the steps.

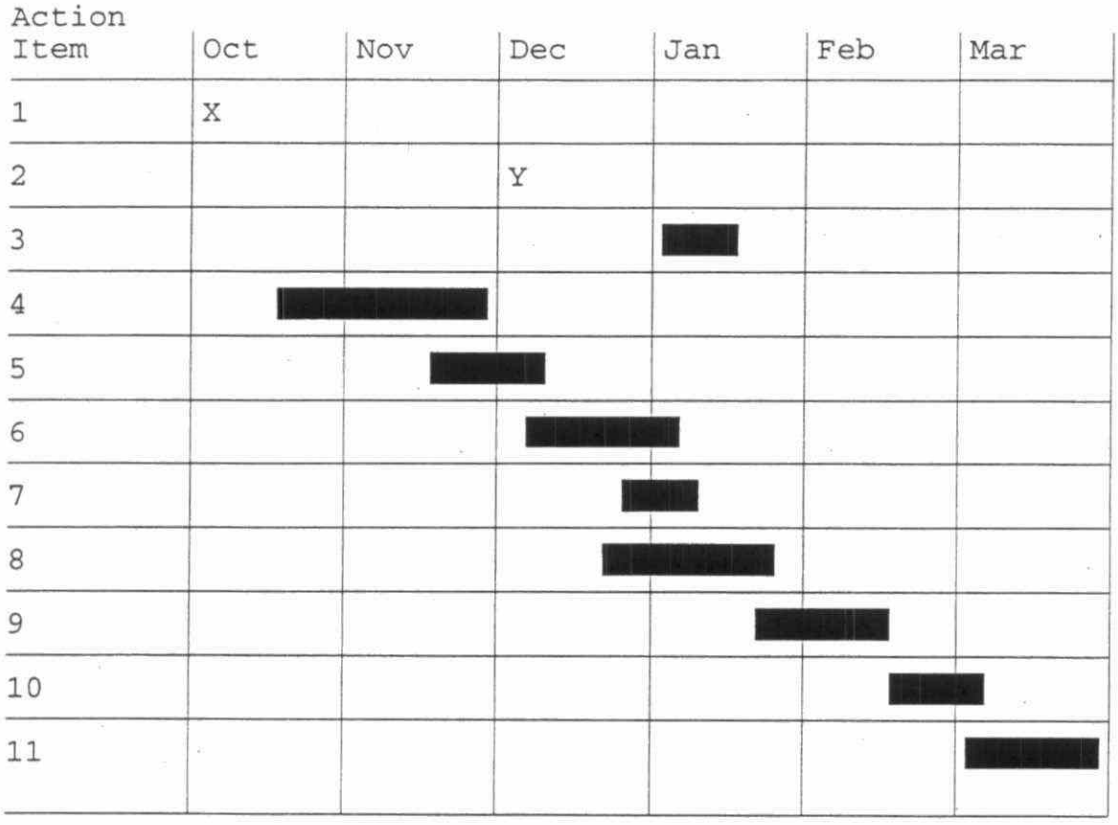
The example we will use is the installation of a new fume scrubber.

FUME SCRUBBER PROJECT

Major activities

1) Order equipment.
2) Delivery of equipment
3) Removal of old scrubber.
4) Modify roof.
5) Install new structural supports.
6) Install new wiring.
7) Install control panel.
8) Install new water lines, and return lines to chromium tanks.
9) Install new scrubber.
10) Test equipment.
11) Train operators.

Gantt Chart



X - Order equipment
Y - Delivery of equipment

As can be seen from the Gantt chart certain activities can be started before the equipment arrives, other activities can be conducted simultaneously. Only a few cannot be started until the old equipment is removed and installation of the new equipment started.
From the chart it would appear that the operation would be without a scrubber for 6 weeks, and probably shut down. This therefore identifies the critical activity. If in fact a 6 week shut down were inevitable, then plans would have to be made to either build inventory to take care of customers needs, or to arrange to sub contact the work. Ideally since this is a potential weak point, steps should be identified in order to reduce this shut down time to a more manageable situation, ie; 2 weeks. This critical step could then be accomplished during the normal shut down periods in the summer or at Christmas.

FINAL APPROVAL AND IMPLEMENTATION

With the implementation plan and knowledge of the expected results, the Team can then approach management to obtain funding approval for purchasing equipment or making the changes. Suppliers can provide

information about the expected results, be they reductions or other benefits, that can help the project be a viable one that is more likely to gain management approval and allocation of funds. In most cases, the supplier can provide references or contacts of plants that have implemented a similar plan and information on their results.

For some projects it may be possible to obtain government funding and/or grants. This avenue should be investigated. It is possible that the equipment suppliers are aware of the funding availability on their equipment. Suppliers should also be approached if the approval of a purchase agreement is not acceptable to management. There may be some lease arrangements or price discounting arrangements that can be made directly with the supplier.

Once the project is approved management should approve the staff assignments in the implementation plan to ensure the completion of the project in an efficient and timely manner. Management should empower the implementation team to obtain the human resources, purchase the equipment and implement the solutions as required.

Upon implementation of the program, the Team must follow the action plan and track its progress in order to make the necessary adjustments for a successful implementation. It is essential to monitor the costs associated with the project, evaluate the progress and measure the effectiveness of the option(s).

MEASURE SOLUTIONS AND SAVINGS

One of the key tasks in this step is to select the appropriate parameters for monitoring the success of the project. Parameters should reflect the changes undertaken and the progress made in terms of both operating costs and wastes reductions. For example, if a chromium solution recycling program is being installed in the plant it may be worthwhile to track the amount of make-up solution required and subsequently the cost savings from reduced chemical and water purchases.

It is important to record and consider all effects, both positive and negative, to ensure that a complete picture of the changes on efficiency are obtained. For example a system installed to purify a solution may not reduce the need for it to be discarded but may have quality benefits (eg. reduction in the number of defects)

In some cases it might be useful to normalize the tracking parameter for easier comparison with other projects, some examples of normalization factors are: surface area of plated material, units produced(if they are always the same workpiece), amount of material used, hours of production or hours of labour. Management may view the project more favourably if they can be shown how the changes will reflect on the bottom line (i.e. production, operating costs).

Once the Team has completed the program and reviewed and evaluated

all information and results, they report on the implemented activities to management and decide on further action(s). Continuous improvement comes about when employees receive recognition for their success. Other employees will be willing to try their hand at reducing wastes, and those already in that frame of mind will continue. The more employees involved in pollution prevention, the better chance it has of becoming an integral part of the business.

SUMMARY

In this step the team generates a detailed implementation plan and cost estimate for the approved solution. They also prepare a communications plan to inform management and employees about the project and a monitoring program to measure the success of the project. The implementation, monitoring and communications plans, cost estimate and approval forms are submitted to management for approval.

STEP 7 REPORT ON IMPLEMENTED SOLUTIONS

Purpose	· To report on implemented pollution prevention undertakings as a measure of the success of the project and to broaden the interest in continuing the programme.
Objectives	· Reporting allows for recognition of individual and team efforts as well as charting the reasons for success or failure. Where possible, progress reporting could also be extended to the agencies responsible for this guide.
Products	· Reports to the participants should be written in normal plant language. External and company reports can use the reporting guide provided with this document, which has been developed with the assistance of several experienced metal finishers.
Time Frame	· For greatest effect, the report(s) should be completed within 10 to 20 days after the completion of the project, with larger companies reporting internally on a quarterly basis. Outside agencies and senior management could be informed on an annual basis.
Tools	· Sample reports are included in this document, but a more basic form for owner-managed companies may be used.
Who	· Report preparation should be inclusive of all those who provided input to the process, with the lead writer contributing the motivation from introduction to conclusion. Outside consulting assistance, too, should be acknowledged.

INTRODUCTION

Ongoing commitment to the pollution prevention process by both senior management and shop floor personnel will be sustained by reporting on successes. Reports do not have to be a paperwork burden for staff. The reporting format should be consistent with the companies culture. Health and safety committee reporting may serve as a good model for the Team.

CONTENT

The content of your reports will recognize team approach, with emphasis on the recording of your efforts and all their results. On the positive side, the following items will be necessary in order to

plot the outcome.

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- how administrative and operative barriers were overcome
- how new information sources were located
- time management relative to the process
- how the programme functioned to reduce the pressure on waste treatment

As well, it should include cost savings, environmental impact, new information sources, legislative barriers and other facets such as process limitations, availability of funds and trained staff, degree of management support and accurate cost accounting and restrictions to substitution due to customer specifications ***(Example 22 page 83)***.

Your final summary should contain a critique of the process with recommendations for improvement and a stated direction for the continuation of the process.

SUMMARY

In this step the team generated reports for management, employees and the public that reported on the progress of the pollution prevention solution.

FACILITY INFORMATION SHEET
METAL FINISHING POLLUTION PREVENTION PROJECT

Facility Identification			
Facility Name	Peerless Plating, Inc.		
Street address	1000 Nowhere Lane		
Street address			
City			
Facility Rep	John Doe (General Manager)		
Postal Code		Telephone Num	
Current Date	August, 1994		

Facility Information			
SIC codes			
Major products	Copper, Nickel, and Chrome plating of automotive parts		
Production (daily)	10,000 parts		
Number of production staff	75	Number of management staff	35
NPRI Identification Number		MOEE Waste Generator Number(s)	
Certificate(s) of Approval [LIST]			
Production processes/ activities			
Existing waste management systems/ practices			

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

FACILITY INFORMATION SHEET
METAL FINISHING POLLUTION PREVENTION PROJECT

Current Environmental Programs: Do you use the following? *Please check*	*Yes*	*No*
Waste management hierarchy	✓	
Materials accounting to identify sources of pollution and activities which create pollution	✓	
Material balance of each process as part of the materials accounting procedures		✓
Cost accounting procedures that incorporate pollution costs and assign the costs to individual processes		✓
Employee involvement in pollution management through training, rewards, solicitation of ideas	✓	
Written pollution prevention program, goals/targets, timetable for pollution prevention	✓	

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

PLAN SUMMARY REPORT
METAL FINISHING POLLUTION PREVENTION PROJECT

Project Identification	
Facility Name	Peerless Plating, Inc.
Project Name	Reduction in chromic acid losses from plating operations
Current Date	February, 1994

Descriptive Summary of Project

It was estimated that the total annual chromic acid losses represent approximately two-thirds of the annual chromic acid purchased. The majority of the losses were found to be caused by reasons other than solution drag out. Sources of chromic acid losses included, tank overfilling during water additions and solution losses through the ventilation system and to the scrubber. Less than 15% of the total chrome purchased was collected in the sludge from the Wastewater Treatment Plant.

It was therefore decided that the reduction effort would focus on losses from the chrome plating operation. Specifically spills from overfilling baths and leaks to the ventilation system were investigated.

Following the procedures as outlined in the Protocol, the Team identified four possible solutions to the problem of chromic acid losses. The pollution prevention option ultimately selected involved the installation of a level control system on the chrome plating baths, complete with high level alarms and automatic shut-offs. This would eliminate the greatest source of chromic acid loss, ie. tank overfilling.

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

PLAN SUMMARY REPORT
METAL FINISHING POLLUTION PREVENTION PROJECT

Information Summary for Project				
Objective	Install appropriate control equipment to eliminate chromic acid losses due to spills.			
Goals	Reduction in chromic acid losses due to spills			
Motivating factors	Reduce losses of chromic acid and save raw material. Reduce treatment and disposal costs.			
Specific waste stream or substance(s) to be addressed	Chromic acid losses due to spills			
Target reduction(s) (%)			50% of CrO_3 losses	
Expected duration to completion (months)			12	
Expected capital investment ($)			$20,000	
Expected annual savings ($)			$5,000	
Place a check mark in the appropriate boxes				
Environmental management hierarchy	poll. prevention	✓	recycle/reuse	
	treatment		disposal	
Pollution prevention	use elimination		use reduction	
	process change		operational change	✓
	equipment change	✓	chemical subs.	
	product change			
Environmental media addressed	air emission		liquid effluent	
	discharge to sewer		onsite disposal	
	offsite transfer		offsite disposal	✓

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

PLAN PROGRESS REPORT
METAL FINISHING POLLUTION PREVENTION PROJECT

Project Identification	
Facility Name	Peerless Plating, Inc.
Project Name	Reduction in chromic acid losses from plating operations
Current Date	August, 1994

Descriptive Summary of Progress on Project
The level control system was installed on the five chrome plating baths on schedule and within the project budget. Over the six month period following installation of the system, no incidents involving tank overfilling occurred. In the previous year, prior to implementation of the level control system, several incidents had occurred. An immediate savings in lost chromic acid was therefore realized.

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

PLAN PROGRESS REPORT
METAL FINISHING POLLUTION PREVENTION PROJECT

Information Summary of Progress on Project	
Specific waste stream(s) or substance(s) addressed	Chromic acid losses to spills
Reduction(s) achieved (%)	35% of chromic acid losses
Duration (months)	12
Capital investment ($)	$20,000
Annual savings ($)	$5,000
Lessons learned	
Barriers encountered	
If activity not pursed, why not?	
Results	To date, a 35% reduction in chromic acid losses has been realized without having any negative effect on production or product quality.
Comments	

Example 22. Peerless Plating Project Report [Form 17 Appendix D]

STEP 8 CONTINUOUS IMPROVEMENT

Purpose	· To integrate pollution prevention in the corporate management plan.
Products/Outputs	· Assign accountability for wastes to operating departments · A tracking and reporting system for pollution prevention projects
Time Frame:	· Effort: 20 - 30 days · Duration: 6 months · Dependent on the complexity of facility
Who:	· Team; Champion · Company staff including management
Tools:	· Benckmarking; Performance Charting

INTRODUCTION

The task of maintaining and improving a viable pollution prevention program is made easier with the integration of pollution prevention into the corporate plan and the establishment of a pollution prevention awareness program.

THE INTEGRATION OF POLLUTION PREVENTION INTO THE CORPORATE PLAN

The integration of pollution prevention into the corporate plan includes:

- assigning accountability for wastes
- tracking and reporting on pollution prevention projects
- conducting an annual evaluation of the program
- staff education
- a public outreach and education program.

Operating units that generate wastes should be accountable and charged with the full costs of continuing and disposing of them. Cost accountability should take into account indirect costs such as potential liability, compliance reporting, and oversight. Burying waste management costs in general overhead can lead to an illusion that disposal is "free." Allocating the costs of waste handling to the operating units that generate them reminds unit managers that waste control and disposal are increasingly large factors in the cost of doing business and motivates them to find ways to cease generating such waste.

The information system should track and retain the data necessary to measure pollution prevention program results. Key performance

measurements should be tracked over time, on a per unit production basis if appropriate. An example would be hazardous waste generated per month, divided by the parts plated. Comparisons with other facilities, where data are available, can be useful. This "benchmarking" exercise is a means of determining how a company compares to performing similar operations. Data are reviewed and reports are prepared at meaningful intervals to enable unit managers to monitor and adjust their operations to adhere to the schedule established during the planning stage. In addition, they need this information to provide feedback to staff.

Management can demonstrate a continuing commitment to the program by conducting annual reviews. The results of these reviews should be communicated to all employees through written announcements and meetings. Successes should be recognized and any changes in objectives or policies announced and explained. If management reviews demonstrate chronic schedule slippage, company executives should meet with the pollution program Team to reevaluate the program. Objectives or the approach to achieving them may need to be adjusted. The purpose is to maintain the same high profile the pollution prevention program had initially.

The most important element of the waste minimization and pollution prevention awareness program is staff education. The training program should include all levels of personnel within the company. The goal is to make each employee aware of waste generation, its impact on the site and the environment and ways which waste can be reduced or eliminated. An awareness program can be incorporated into the general orientation given to all new employees. More detailed training should be provided to new employees after they have been on the job for a few weeks. This training will provide them with the skills they need to participate in pollution prevention. It also emphasizes the company's commitment. At many plants, employees in certain jobs must be trained and examined on their knowledge of standard operating procedures specific to the site prior to working there. Pollution prevention training can be incorporated at this point. It can also be incorporated in the Quality Assurance procedures qualification process. Specialized training sessions on pollution prevention policy, procedures, and techniques should be provided to staff when their job scope is expanded or when they transfer to other areas in the company. These sessions should be considered part of the regular training program and managers should have funds allocated to cover such costs.

The public outreach and education program could include employee presentations at meetings of community organizations and at schools to publicize the company's pollution prevention progress. Interviews with local media are another way to enhance corporate image and to further emphasize to employees the importance of the program. Papers given at technical meetings and articles published in trade and professional journals are additional forms of positive publicity. These measures all help to demonstrate that the company's commitment

to pollution prevention is real.

POLLUTION PREVENTION AWARENESS PROGRAM

A pollution prevention awareness program is intended to promote employee involvement in the prevention effort. The objectives of the pollution prevention awareness program are to:

- raise awareness of environment-related activities at the facility;
- inform employees of specific environmental issues;
- recognize employees for pollution prevention efforts; and
- encourage employees participation in pollution prevention.

Employees need to identify with and "buy in" to goals and objectives and continually have the opportunity to contribute to its success. Employees take their pollution prevention roles more seriously when their managers keep them informed and encourage them to submit pollution prevention ideas. Employees should receive regularly scheduled status reports that are clear and accurate. Objectives described in vague terms with poorly quantified results issued at odd intervals may give the impression of a reduced priority for pollution prevention. Explain to the staff any schedule delays resulting from unexpected challenges and the need for greater staff involvement.

Employees' ideas for projects should be actively sought. Forums such as breakfasts or informal review meetings promote the exchange of information that can help generate new ideas. Suggestion programs or contests to solicit and reward employee input can be helpful. For example, you could post a checklist of pollution prevention ideas and offer cash awards for the best way to implement an idea and for the best idea that was not included on the checklist.

Suggestions should be evaluated promptly and put into practice if they are found to be feasible. Similarly, if an employee submits an idea that is not implemented, explain why it was not used and work with the employee to develop a more appropriate idea. Prompt feedback is necessary to maintain employee interest.

Progress in pollution prevention can be stated as an objective on which annual job performance evaluations are based, particularly at the management level. This delineates responsibility for maintaining and enhancing the pollution prevention program. Using the formal mechanism of the written annual report to recognize efforts in this area raises the visibility of pollution prevention as something that is important to the company.

Employees who suggest pollution prevention measures that prove feasible and are slated for implementation should be publicized in the company newsletter or on bulletin boards. The estimated cost savings and/or other advantages that the company or unit will derive should be included in this announcement. Periodic group meetings are

a good forum for announcing individuals' efforts to control pollution in the company's daily operations.

Cash or merchandise can be awarded to individuals. Establishing the award as a set percentage of the estimated annual savings to be realized by the company or production unit is one way to highlight the concrete value of pollution prevention.

SUMMARY

In this step the team examined, developed and implemented proposals for integrating a pollution prevention program into the facility's management plan. The Team should return to Step 3 and repeat steps 3 to 7 for the wastes not addressed in the first cycle.

METAL FINISHING POLLUTION PREVENTION GUIDE

APPENDICES

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Automotive Parts Manufacturers' Association
Metal Finishing Suppliers Association
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September 1995

NOTICE

This document serves as advisory guidance to metal finishers for developing and implementing pollution prevention plans.

The Metal Finishing Pollution Prevention Task Force reviewed and approved the manual for publication. Approval does not necessarily reflect the views and/or policies of the Ontario Ministry of Environment and Energy, Environment Canada, the Canadian Association of Metal Finishers, the American Electroplaters and Surface Finishers Society, the Automotive Parts Manufacturers Association and the Metal Finishers Suppliers Association.

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This guidance document in no way diminishes or varies a facility's responsibilities under federal, provincial or municipal laws, either existing or coming into effect.

PREFACE

Metal finishing facilities generate large quantities of both hazardous and nonhazardous wastes. These wastes result from machinery, cleaning, pickling, plating, conversion coating and other finishing operations. Reducing these wastes at the source will benefit the metal finishing industry and reduce raw material needs and disposal costs and lower the regulatory cost and liability associated with hazardous waste disposal. In fact, many companies have decided to set a zero-water-discharges long term goal.

This manual provides guidance to metal finishers for incorporating pollution prevention planning into their everyday business activities. If followed, the principles outlined in the guide will prepare the metal finisher for the future from both business and environmental perspectives. This guide provides procedures to assess pollution concerns and help a pollution prevention team in identifying, prioritizing and implementing solutions to pollution problems.

ACKNOWLEDGEMENTS

Many organizations and individuals cooperated in the preparation of this Guide. We include and thank everyone who devoted many days to help plan, write, edit and reedit this manual. We hope it will become a useful tool for all metal finishers.

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APPENDIX A: ACRONYMS AND DEFINITIONS

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ACRONYMS

AESF	American Electroplaters and Surface Finishers Society
APMA	Automotive Parts Manufacturers' Association
ARETS	Accelerated Reduction/Elimination of Toxic Substances; new Federal program
BAT(EA)	Best Available Technology (Economically Achievable)
BMP	Best Management Practices
CAMF	Canadian Association of Metal Finishers
CAP	Clean Air Program; Ontario government initiative
CCME	Canadian Council of Ministers of the Environment
CCOHS	Canadian Centre for Occupational Health and Safety
CEPA	Canadian Environmental Protection Act; Federal legislation
CERCLA	[US] Comprehensive Environmental Response, Compensation and Liability Act (1990) (also known as Superfund)
CIPEC	Canadian Industry Program for Energy Conservation
EMPPL	Effluent Monitoring Priority Pollutants List (MOE)
GLWQA	Great Lakes Water Quality Agreement, a joint Canada-US plan adopted in 1972, amended in 1987, to resolve to pollution in the Great Lakes.
MFI	Metal Finishing Industry
MFP3	Metal Finishing Pollution Prevention Program
MFSA	Metal Finishers Suppliers Association
MISA	"Municipal Industrial Strategy for Abatement," Ontario's Ministry of the Environment's program to achieve reduced (and/or virtual elimination of) discharges of persistent toxics from Ontario municipal and industrial sources
MSDS	Material Safety Data Sheets
MVMA	Motor Vehicles Manufacturers' Association
NAMF	National Association of Metal Finishers
NDG	New Directions Group
NO_X/VOCs	Oxidized nitrogen compounds and volatile organic compounds, which are ground level ozone precursors
NPDES	National Pollutant Discharge Elimination System (US EPA)
NPRI	National Pollutant Release Inventory; new federal program
OSHA	[US] Occupational Safety and Health Administration; 27 specific chemical standards
PC	Printed Circuit (industry)
PSL	Priority Substances List, under CEPA and currently (07/04/92) includes 44 substances
RCRA	[US] Resource Conservation and Recovery Act (1976)
STP	Sewage Treatment Plant
TQEM	Total Quality Environmental Management
TRP	Toxic Reduction Plan
TSCA	[US] Toxic Substances Control Act (1976)
WHMIS	Workplace Hazardous Materials Information System
WTP	Waste water Treatment Plant

APPENDIX B: TOOLS AND TECHNIQUES

APPENDIX B: TOOLS AND TECHNIQUES

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APPENDIX B: TOOLS AND TECHNIQUES

DEFINITIONS OF POLLUTION PREVENTION TERMS

Audit (Assessment)

For the purposes of this program, an audit (or assessment) is an activity to collect relevant data and information which permits a determination of the environmental status of a metal finishing facility. Synonyms of "audit" include: assessment, evaluation, review, survey.

"Auditing is an examination of the procedures and practices of a facility to verify compliance with the legal requirements, internal policies and accepted practices. Auditing requires collection and documentation of competent and sufficient evidence . . . " (Greeno, 1985).

Metal Finishing

Surface addition(s) or conversion(s) that enhances the usefulness of the base product.

Persistent Toxics

Persistent toxics are all toxics that have a chemical "half-life [in surface water] greater than eight (8) weeks" (IJC, 1992) . . . that cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring" (MOE, 1991); and "... those chemicals having a bioconcentration factor greater than 100 to 250" (IJC, per Bicknell, 1992).

Pollution Prevention

Pollution Prevention is "any action which reduces or eliminates the creation of pollutants or wastes at the source, achieved through activities which promote, encourage or require changes in the basic behavioral patterns of industrial, commercial and institutional generators or individuals." (MOEE Pollution Prevention Office, 1992)

Pollution prevention is the reduction or elimination of wastes through processes, practices or technologies that reduce or eliminate the volume and/or toxicity of wastes. Pollution prevention promotes the efficient use of resources that includes the avoidance of cross media transfer of pollutants.

Pollution prevention can be achieved by:

1) design of, or changes in, production technologies or processes, raw materials, manufactured products and energy or use of substitute materials that result in the reduction of:

- the demand or use for hazardous substances per unit of production
- creation of hazardous products
- creation of by-products, contaminants, or fugitive emissions
- for each unit of production, will reduce the amount of hazardous waste generated and disposed of onto land or discharged into the air or water
- reduce or eliminate, without shifting, the risks that the use of hazardous substances at an industrial facility pose to employees, consumers or the environment
- adverse impacts (on the environment and human health)

Examples of these changes are: raw material substitution, reformulated product, production process redesign or modification, in-process recycling, improved operation and maintenance of production process equipment.

2) reduction of the use of energy through:

- more energy efficient technology
- the decrease in use of energy consuming products (eg. automobile use)
- development of a more efficient transportation network

3) changes in consumer and household behaviour that result in:

- reduced demand for hazardous products
- reduced consumption of energy
- reduction in production of waste or (other) pollution

Pollution prevention <u>does not</u> include:

- Any action or change that substitutes one hazardous substance, product, or waste for another and results in the creation of new and/or increased risks.
- Waste treatment, increased pollution control, out-of-process recycling, or incineration.
- The elimination of a hazardous substance release by discharging it to another medium, transferring it to products or the workplace.

The "Environmental Management Options" hierarchy is shown in the following ***Figure 1***. Only <u>source reduction</u> and <u>on-site recycling</u> are accepted pollution prevention practices. The other choices in the hierarchy acknowledge the creation of a waste.

<u>Prevention (Source Reduction):</u>

- product substitution or conservation
- change in product composition
- material purification or substitution

Figure 1 Environmental Management Hierarchy

- process, equipment changes
- changes in operations and/or process automation
- Baps

Recycling (& Reuse; on/off-site):

- reuse in original process
- recycle as substitute for other process
- process for resource recovery or by-product

Treatment:

- End-of-pipe treatment

Safe Disposal:

- Acceptable, reliable wastes management **Source Reduction** means any practice which:

(1) reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) before recycling, treatment, or disposal; and

(2) reduces the hazards to public health and the environment related to the release of such substances, pollutants, or contaminants.

The term includes equipment or technology modifications, process or procedure modifications, redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

Source reduction

Source reduction is an extension of waste management and end-of-pipe treatment to solve waste problems. It includes the following measures: (1) process modifications, (2) in-process recycling, (3) housekeeping improvements, (4) inventory control, (5) raw material substitution, and (6) end-product substitution.

The term "source reduction" excludes any practice that alters the physical, chemical or biological characteristics or volume of a hazardous substance, pollutant or contaminant through an activity that is not integral to the production of a product or the providing of a service. (US, 1990)

Sunsetting

"An approach to restrict, phase out, and eventually ban the manufacture, generation, transport, storage, discharge, and disposal of persistent toxic substances. The approach requires consideration of the manufacturing process, products associated with the chemical's production and use, and the chemical itself." (IJC, per Wilkins, 1992)

Toxics use reduction

Toxics use reduction (NJ Law Development Committee) includes changes in production processes, products or raw chemicals that reduce or eliminate the use or creation of toxic chemicals per unit of production, to reduce the total risks to health of workers, consumers or the environment without shifting the risks between workers, consumers and the environment.

Toxics use reduction addresses all destinations of a toxic chemical in a production process: in the product, in wastes, or consumed by the processes. Toxics use reduction shifts the focus to the front end of the production process - the materials entering the process and the design of products.

Toxic use reduction includes the following measures: (1) process modifications, (2) in-process recycling, (3) housekeeping improvements, (4) inventory control, (5) raw material substitution, and (6) end-product substitution.

Virtual elimination

"... an overall strategy, focusing on preventive and remedial approaches, to achieve the GLWQA goal of restoring and maintaining ecosystem health . . . [" . . . 'virtual' because it is not practical to completely remove all persistent toxics which were previously released . . . "] (MOE, 1991).

Zero discharge

"... no release of specific toxic substances to the ecosystem." (MOE, 1991)

Toxics (Toxic substances)

Substances "that cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring." (MOE, 1991).

Waste

Waste is any resource that does not add value to the product or

service for the customer.
Waste, for the purposes of this program, is any material, used within an operation, which leaves a facility, by whatever means other than as part of the finished product. The "lost" material may still have a value (either positive or negative), which is related to the original purchase cost, the cost to render it nonhazardous, or the ultimate disposal cost.

Waste Management Hierarchy

A modification of the Environmental Management hierarchy presented in ***Figure 1*** "flows from source reduction, to reuse, to on-site recycling, to off-site recycling, to treatment and disposal. (Foecke, 1992).

TOTAL QUALITY MANAGEMENT TECHNIQUES

Total Quality Management (TQM) is an organized system that includes customers, suppliers, managers, workers, equipment and finances (literally everything) involved in the manufacture of products.

The establishment of a pollution prevention program at a facility can be easily accomplished using the logical, systematic approach shown in ***Figure 2***. By applying the basic principles of "Total Quality Management" (TQM) to the assessment of pollution at the facility, the company's employees are motivated to become involved in the entire pollution prevention process. The other essential principles of a TQM system are similarly applicable to the pollution prevention planning process, including:

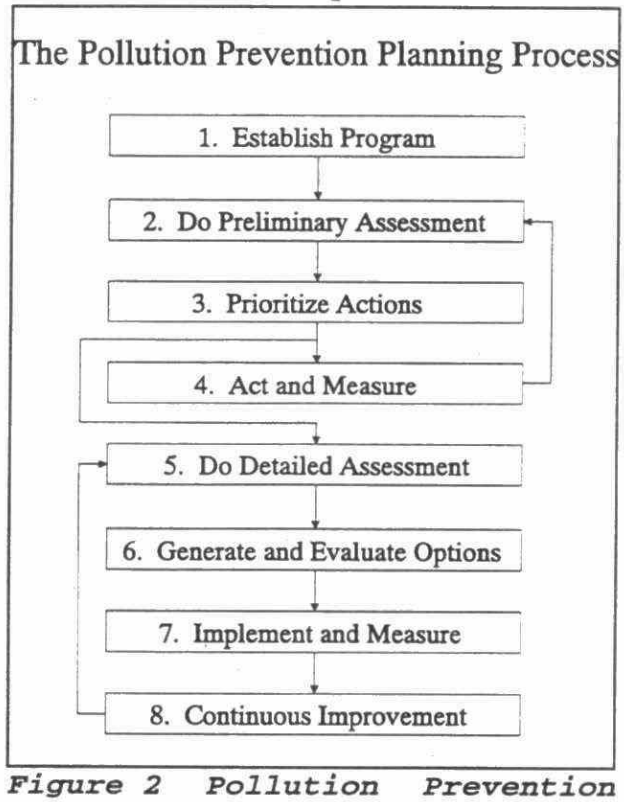


Figure 2 Pollution Prevention Planning Process

- CEO or plant manager's vision, commitment and participation;
- employee education and empowerment;
- exceeding customer requirements;
- systematic review of processes;
- Setting priorities and carrying out options;
- use of success stories, recognition, reporting;
- communication inside and outside company;
- continuous improvement.

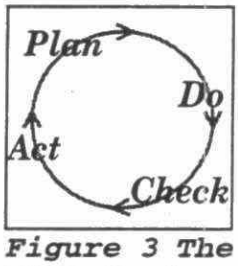


Figure 3 The PDCA Cycle

Note that the 8 Step Process represents two cycles of the Deming Shewhart Cycle. The Deming Shewhart cycle (PDCA cycle) presented in ***Figure 3*** encourages the continuous evaluation and improvement of a process, until the process results in zero defects.

TQM involves the carrying out of certain strategies, such as:

- changing the corporate culture;
- making the customer the focus of the business;
- instigating continuous process improvement;
- Carrying out self directed high performance teams;
- integrating business and quality planning; and
- increasing profits by reducing costs for corporate survival.

Deming's Fourteen Points towards TQM

1. Create a constancy of purpose for the improvement of product and service.
2. Adopt the new philosophy in which mistakes and negativism is unacceptable.
3. Focus on improving the process.
4. Establish long-term supplier relationships based on material quality.
5. Constantly improve the system of production and service.
6. Institute training so each worker can do a consistent and proper job.
7. Institute leadership and empower people to do a better job.
8. Eliminate fear and encourage employees not to be afraid to ask questions in clarifying their roles or duties.
9. Break down barriers between staff areas and encourage company wide cooperation in projects.
10. Eliminate slogans, exhortations and targets for the workforce.
11. Eliminate numerical quotas.
12. Remove barriers to pride of workmanship.
13. Begin a vigorous program of education and retraining, ensuring that everyone in the company understands the new methods, teamwork and statistical techniques.
14. Take action to accomplish the transformation, starting with top management, ensuring full company participation.

TQM's Seven Deadly Diseases

1. Lack of constancy of purpose
2. Emphasis on short-term profits
3. Evaluation by performance, merit rating, or annual review of performance.
4. Management mobility that results in "job hoppers" who never understand the companies they work for.
5. Running a company on visible figures alone.
6. Excessive medical costs for employee health care. (US situation)
7. Excessive warranty costs, fuelled by lawyers' contingency fees. (US situation)

Obstacles (or Barriers) to Quality Transformation

- Neglect of long range planning and transformation.
- Expectations that solving problems, automation, gadgets and new machinery will transform industry.
- Need for examples, or case studies, as models.
- Obsolescence in the school system.
- Reliance on quality control departments.
- Quality inspection.
- Blaming the workforce for problems.
- False starts.
- Inefficient use of equipment.
- Meeting specifications
- Inadequate testing of prototypes.
- The notion that help can only come from someone with an intimate knowledge of the facility.

"Lack of total commitment by upper management to participate is the greatest hurdle to overcome" (Piplani, 1993). In other words, the company and employees will be encouraged to participate in pollution prevention, knowing that management are supportive of the system.

Tools that are useful or essential in setting up TQM in a facility are described in the following.

Brainstorming

Brainstorming involves the collection of information in a group setting, where all ideas are considered relevant. The method explores all possibilities by obtaining ideas from every member of the team. Each member offers suggestions or recommendations during a session on the selected subject. All ideas offered are recorded or listed for later review in the meeting. No idea or suggestion is criticized by any other member of the Team. Certain rules must be applied to a brainstorming session for it to be a successful and productive exercise.

- Avoid all criticism and evaluation of ideas
- Exaggerated ideas are welcomed
- Encourage QUANTITY -- the greater the number of ideas, the greater the likelihood of good ones
- Encourage building on others' ideas
- Stimulate participation
- Record all ideas

Control Chart

The control chart is one of the "seven simple statistical tools" (Walton, 1986) that aids in providing the useful facts needed to make effective decisions about pollution prevention.

Control charts presented in ***Figure 4*** record process variability over

time. The upper (UCl) and lower (LCl) control limits are statistically determined limits on either side of the average value ($\bar{X}$) of the process results. The size of the difference between the upper and lower control limits, compared with the average value, will show the amount of measured variability in the process. The greater the difference between ULL and LCl, the greater the variability in the process.

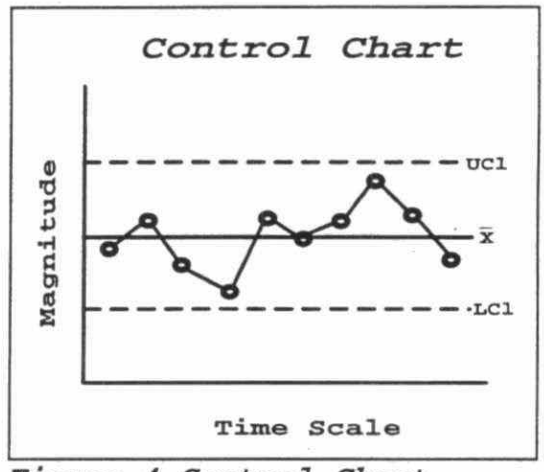


Figure 4 Control Chart

Fishbone (Cause and Effect Diagram)

The Fishbone diagram is one of the "seven simple statistical tools" (Walton, 1986) that aids in providing the useful facts needed to make effective decisions about pollution prevention. The "Ishikawa diagram" presented in ***Figure 5*** (also known as a "fishbone" diagram due to its appearance) is a method of mapping out a list of factors contributing to a problem.

A Fishbone diagram identifies and categorizes all root causes for the waste concern under discussion. Root causes are offered by members of the team and are recorded on the diagram as to the impact or result in the following categories:

- People
- Procedure
- Machine
- Material

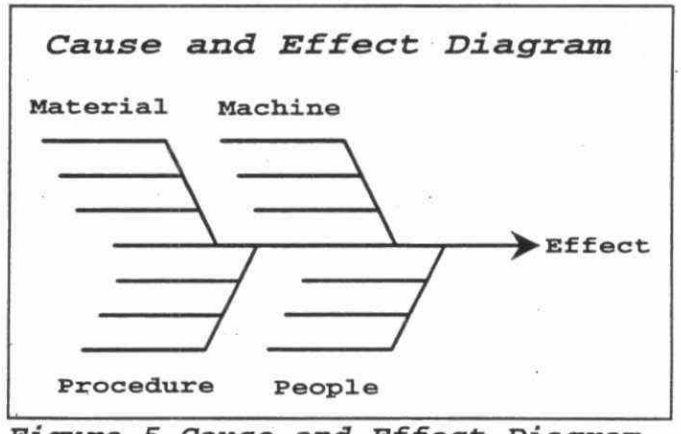


Figure 5 Cause and Effect Diagram

As in the brainstorming session, each member offers a suggestion that is placed on the fishbone diagram under the appropriate category. See also the discussion under **Root Cause Analysis**.

Flow Chart

The Flow Chart is one of the "seven simple statistical tools" (Walton, 1986) used to provide useful facts needed to make effective decisions about pollution prevention.

The flow chart presented in ***Figure 6*** offers a visual representation of the sequence of steps in the plating process. It explains the relationships between the various sequences and aids in the calculation of material flows.

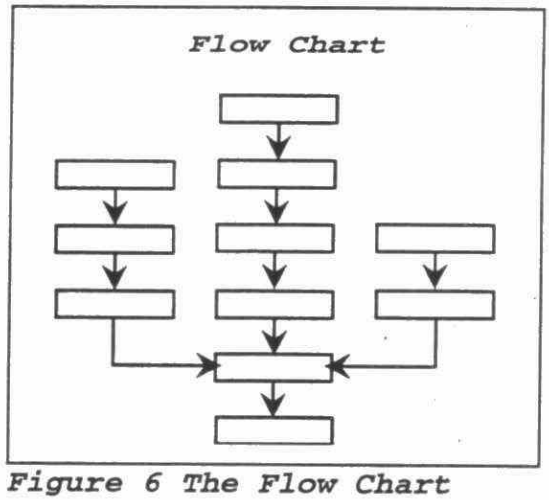


Figure 6 The Flow Chart

Histogram

The Histogram is one of the "seven simple statistical tools" (Walton, 1986) used to provide useful facts needed to make effective decisions about pollution prevention.

Histograms presented in ***Figure 7*** provide frequency distributions of the results from a process. They offer a graphical presentation of the responses that result from a process.

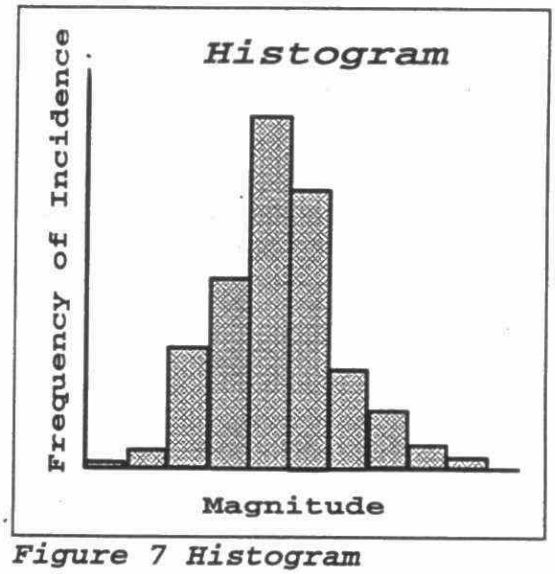


Figure 7 Histogram

Material Balance

In its simplest form, the material balance is represented by the mass conservation principle:

Mass in = Mass out

By definition, the material balance includes both materials entering and leaving a process. Typical sources of information for conducting the material balance are as follows:

- Samples, analysis, and flow measurements of feed stocks, products, and waste streams

- Raw material purchase records
- Material inventories
- Emission inventories
- Equipment cleaning and validation procedures
- Batch makeup records
- Product specifications
- Production records
- Standard operating procedures and/or logs
- Waste manifests

Material balances are easier, more meaningful, and more accurate when they are done for individual units, operations, or processes. Also, the time span is important when constructing a material balance. Material balances conducted over a short period require more accurate and more frequent stream monitoring to close the balance. Material balances conducted over the duration of a complete production run are typically the easier to construct and are more accurate. Actual measurements are best. Indirect methods, such as calculating by difference or using purchase records, are subject to error.

Multi-Voting

One method of selecting the most significant items from a list of many is through a process known as multi-voting. This is a well-known method of setting priorities. Each member of the team receives a few votes and selects the items that are the most important. An enhanced method of multi-voting incorporates a ranking technique. For example, if a member had a total of five votes, then a ranking of five is given to the item that the member felt was most important. The next greatest concern would receive a ranking of four, and so on until the final vote has been cast. After all members have voted, the scores are totalled producing a ranked list of concerns. The item with the highest score should not automatically be accepted by the team as the most important concern. At minimum, a few of the top ranked concerns should be discussed, with a final decision reached by team consensus.

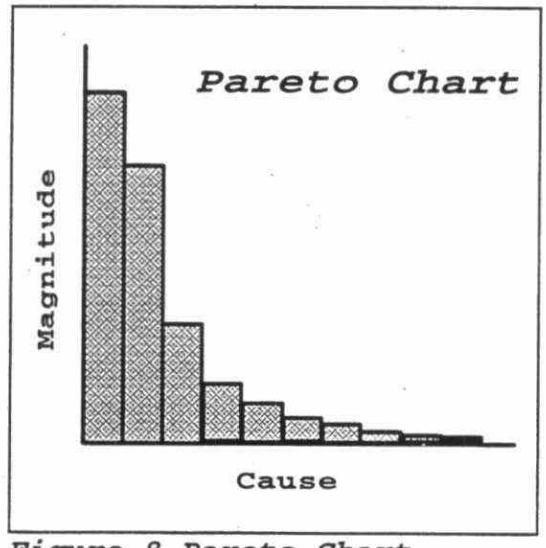


Figure 8 Pareto Chart

Pareto Analysis

The Pareto Chart is one of the "seven simple statistical tools" (Walton, 1986) used to provide useful facts needed to make effective decisions about pollution prevention.

The pareto chart in ***Figure 8*** is used to arrange data in a way that makes comparisons easy. Sometimes called the "80/20 Rule", the Pareto chart is named after the 19th century economist who discovered that 80% of the wealth in Central Europe was controlled by only 20% of the population. Similarly, this principle is applied to waste generation, since it is likely that 80% of the waste at a plant comes from 20% of the processes, and 80% of the mass of a particular waste stream comes from 20% of the causes, etc.. This method of analysis can be very useful in weeding out the "trivial many" (80%) from the "vital few" (20%).

Root Cause Analysis

A problem or waste stream is linked to several causes. The list of causes are generated through a brain storming exercise. It is important to note that some causes are related. If this occurs, team members should strive to identify the underlying *root* causes, since these are the issues that once resolved lead to permanent solutions to the problem. A useful technique in doing this is asking the question *Why?* several times.

For example, if leaky pumps were judged to be the most significant waste problem, and broken pump seals were identified as the likely cause, the solution would be to replace the broken seals. This is a "Band-Aid" solution that will never resolve the problem since the actual root cause was not identified. If the team used the *"Why"* technique, the actual root cause would have been identified and the problem would have been eliminated.

The questions that should have been asked are as follows:

> Q: "Why did the seals break?" *A: There was too much friction inside the pump.*
>
> Q: "Why was there so much friction?" *A: Pumps were not properly lubricated.*
>
> Q: "Why were the pumps not properly lubricated?" *A: Nobody delegated to maintain pumps.*
>
> Q: "Why wasn't anyone delegated to maintain them?" *A: No preventive maintenance program.*

As you can see from the above example, asking *why* enables the team to thoroughly investigate the problem. Otherwise the primary root cause, i.e., the lack of a preventive maintenance program, may not be identified. Likewise, the best solution to the problem (setting up a preventive maintenance program) is overlooked.

It is useful to list each root cause and categorize each on a "Fishbone Diagram" See explanation of the diagram under **Fishbone**.

Run Chart (Trend Chart)

The Run Chart is one of the "seven simple statistical tools" (Walton, 1986) used to provide useful facts needed to make effective decisions about pollution prevention.

The Run Chart presented in ***Figure 9*** provides a graphical presentation of the trend in a process over a time .

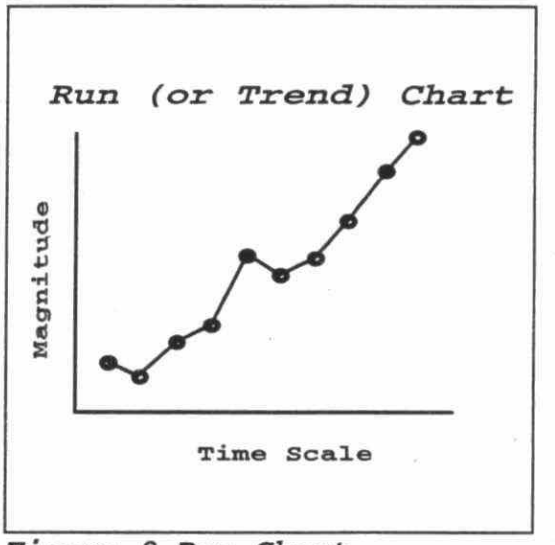


Figure 9 Run Chart

Scatter Diagram

The Scatter Diagram is one of the "seven simple statistical tools" (Walton, 1986) used to provide useful facts needed to make effective decisions about pollution prevention.

A graphical presentation of the relationship of one variable to another presented in ***Figure 10***. A wide scatter represents poor control of a process or a high variability in the process.

Weighting

Weighting is a statistical tool used to selectively rank priorities from the most important to the least important. It permits a biasing of the more important criteria during ranking of waste concerns. Integer values from one to three are used to rank criteria from the most important (3) to the least important (1).

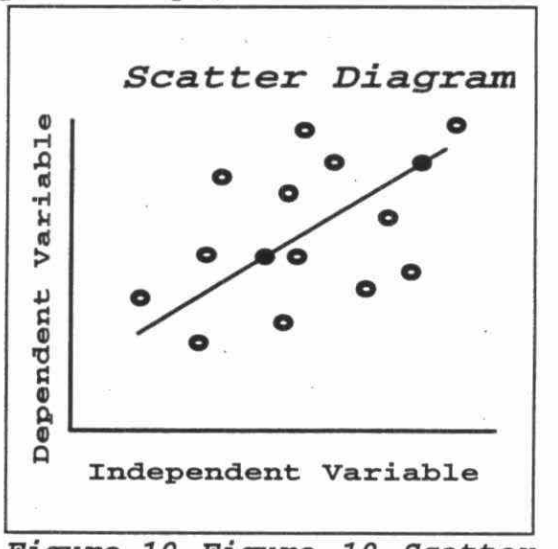


Figure 10 Figure 10 Scatter Diagram

DATA COLLECTION METHODOLOGIES

Sampling

Sampling plays a vitally important part in controlling industrial wastes. If it is not done properly, the conclusions drawn from an inspection or survey will be meaningless. There are many important things to consider while establishing a sampling program.

Basic Considerations

Representation and Uncertainty

A sample is "a portion or part taken as representative of the whole." The smaller the portion, the greater is the uncertainty that the sample represents the whole. The objective in sampling is to obtain as good a representation as is practicable. Generally, the greater the number of samples taken, the better is the representation.

Samples must be as representative as technology will allow and the methods and procedures used in obtaining the samples must reflect this.

Pre-Sampling Steps

The first planning step, is a review of the objectives of the survey. For example, if the purpose of the survey is to find the quantity of a pollutant being discharged during a twenty-four hour processing day, there is no point in taking a single portion only. Take many portions to assure good results.

The second pre-sampling step is to observe the process or processes that produce the waste stream. Include a preliminary measurement of flow rates and their variation during the processing period if possible.

Thirdly, select the sample points. Be sure that the chosen points will provide data consistent with the objectives of the survey. For example, if the objective is the relative contribution of two process streams that merge, at least one sampling point must be upstream of the convergence. Samples taken downstream of the mixing point must be sufficiently far downstream to ensure that complete mixing has taken place.

The following records can then be made:

(a) the number and location of sampling points
(b) the type of samples
(c) the frequency of sampling
(d) the duration of the sampling period
(e) the analyses required
(f) any other pertinent factors (i.e., labour & equipment needs)

Location of the Sampling Point

The location of the sampling point is important to obtain a proper result. In certain cases, especially where merging streams are large and slow-moving, streams do not completely mix for a considerable distance. If this is suspected, a dye can be added to one stream to find out the point of complete mixing. Sample a large open channel in the middle of the channel and at approximately one-third of the depth. This will provide the most representative sample. Sample where the waste steam is as thoroughly mixed as possible. Incompletely mixed locations include: immediately above a weir, immediately below a weir, immediately downstream of a sharp bend in a large sewer, etc.

Type of Sampling Point

The sampling method and the equipment also depends upon the type of sampling point. The technique and apparatus used to sample a small deep manhole is different from that used to sample the liquid contained in a large tank. Again, obtain a sample as representative of the whole as possible.

When sampling from a valve on a pipe, the liquid should be run for a few seconds before the sample is taken.

When sampling directly from a tank, be sure the solution is well mixed. Avoid skimming a sample from the surface as this is not usually representative of the bulk solution in the tank.

Other Considerations

Samples may be obtained in many ways. The technique and equipment used will depend on the waste stream characteristics, the location, type of sampling, the size of the sample, the composite sample interval and the duration of the sampling period.

The following characteristics must be considered:

(a) the velocity of the flow
(b) the presence of floating liquids such as oil
(c) the presence of heavy suspended solid material
(d) the presence of heavy liquids upon which the water may float.

Sample Types and Techniques

Grab Sample

A grab sample represents the waste water stream at a given point in time as opposed to a composite sample which represents the waste water stream over a longer period (i.e., 24 hours). Grab samples can be collected by using an automated sampling device in the manual mode, or by dipping an appropriate container, bucket, bottle or vial,

into the waste water stream using an appropriate retrieval device such as a chain, rope, or pole if necessary. The equipment used must be made out of a material suitable to the sample stream and analysis being performed (i.e., Teflon, stainless steel, glass, etc.). Grab samples collected for analysis of compatible parameters may be combined in a single large container and subdivided later. They may also be collected in containers dedicated to a specific analysis. Proper preservation techniques must then be followed.

A grab sample is adequate whenever characterization of a stream at a given point in time is required. This type of sample does not give a good representation of a waste stream which is variable in flow and concentration of the parameters being analyzed, however, it often provides sufficient information for a preliminary assessment of waste stream composition.

Composite Sample

A composite sample represents the average characteristics of the waste flow over the survey period. It may be used with the flow rate over the same period to calculate waste load. Composite samples should be used whenever an accurate estimate of waste stream load is required and the flow rates and/or concentrations are variable.

Composite sampling is nothing more than a series of grab samples. Equal volumes are sampled repeatedly at a given interval regardless of the flow rate of the waste stream. This is known as a "time proportional" composite. Better yet, the volume sampled may be made proportional to the flow rate of the waste stream at each sampling interval. This is known as a "flow proportional" composite, and has the advantage of giving a more accurate estimate of contaminant loadings. This is important where a high degree of flow variability exists. Where flows are constant, equal volume/equal time sampling is usually sufficient.

Composite samples can be collected by either automated or manual methods. As mentioned, automated composite samples can be taken proportional to flow (in which cases there must be flow sensing devices connected to the sampler) or on a time proportional basis. Both approaches can be easily accomplished using automated, programmable sampling devices. The same composite sampling can also be achieved by manual means. Manual composite samples are typically taken on an equal volume/equal time basis but can be combined in proportion to flow once all sub-samples have been collected if the flow rate is measured at each sampling interval.

Whether automatic or manual sampling techniques are used, there are two types of composite samples.

(1) those in which the grab samples are kept separate and analyzed separately; and
(2) those in which the grab samples are combined to form a bulk

sample, all or part of which is subjected to analysis.

Both types enable the average characteristics of the waste flow to be found but the former also enables the variations to be clearly seen. Where grab samples are collected as part of a composite for oil & grease analysis, volatiles, or sulphide, each individual container must be submitted for analysis.

Compositing Techniques

Where a sample is collected in a large container and requires analysis for several groups of compounds, the waste water must be allocated into the appropriate laboratory containers. Teflon tubing and gravity suction is recommended for transfer of the waste water to the individual container. The sample may also be transferred to the individual container laboratory container by pouring with extreme care to avoid turbulence. These allocating activities must be accompanied by continuous mixing of the composite sample by using a mechanical stirrer, manual swirling or other appropriate means. A magnetic stirring bar may adsorb suspended solids containing metals, thus destroying the sample integrity.

Sampling Specifics

Sample Volume/Preservation/Analysis

Many decisions must be made when collecting a sample including the type of sample, the type and size of the container, preservation of the sample, analysis to be performed, etc. Table 1 may be used as a helpful reference guide. However, the best method of treatment and analysis for a sample is sample specific. For example, the volume of the sample required is really dependent upon the method of analysis and the concentration of the parameters being analyzed. In a concentrated plating bath, only a small volume of solution may be required since many dilutions must be made before completing the analysis.

For more detailed information regarding sampling techniques and analysis, refer to the Ministry of the Environment and Energy's (MOEE) *Municipal/Industrial Strategy for Abatement (MISA)* protocol entitled, *"Draft Protocol for the Sampling and Analysis of Industrial/Municipal Waste water."*

Table 1. Sample Collection, Preparation, & Preservation for Parameters Typical to the Metal Finishing Industry

PARAMETER	BOTTLE TYPE	SAMPLE SIZE, mL	FILTER, 0.45 um	PRESERVATION	ANALYSIS	NOTES
Indicators						
pH	P or G	100	No		A	
Oil & Grease	G	1000	No	H_2SO_4 pH<2	B	
TOC	G	100	No	H_2SO_4 pH<2	C	
DOC	G	100	Yes	H_2SO_4 pH<2	C	
TSS	P or G	500	No		D	
TDS	P or G	100	Yes		D	
Conductivity	P or G	100	No		E	
BOD_5		100	No	4°C	F	
Surfactants (MBAS/CTAS)	P or G	500	No	none	G	
Metals			No	HNO_3 pH<2	H	
Hg		100		HNO_3 pH<2 + 1mL 5% $K_2Cr_2O_7$	I	
As, Sb, Se		100		HNO_3 pH<2	J	
Cr^{+6}	P or G	100		4°C	K	
Anions			No		L	
NO_2,NO_3,NH_3		100	Yes	HCl pH<2	M	
CN_T,CN_W,CNO,CNS			No	NaOH pH 12	N	CAUTION, toxic
$S^=$	P or G	100	No	1mL 10% zinc acetate	O	
Organics						
Phenol		100	Yes	NaOH pH 12	P	?NaOH
VOC's						

Notes:

1. P,G: Plastic, Glass
2. Analyses

A - pH meter
H - AA/DCAP/IC
I - AA - cold vapour
J - AA - hydride
K - colorimetric
G - extraction + colourimetric
B - extraction + gravimetric
F - DO meter
D - gravimetric
P - distillation + colorimetric
O - distillation + titration
M - autoanalyzer
C - TOC analyzer
N - digestion + colorimetric
E - conductivity meter
L - ion chromatography

FLOW MEASUREMENT TECHNIQUES

The measurement of flow rates within a facility is useful in many ways. It is essential for the completion of a water balance, which shows the distribution of water use throughout the plant. Also, if concentration data from liquid waste streams are considered with the flow volume over the same period, waste loadings may be calculated. Since there are many flowing liquid streams within a facility, a variety of flow measuring techniques must usually be employed.

There are several techniques used for liquid flow measurement. The condition of the flow to be measured dictates the appropriate method. Conditions of flow that may be found in the metal finishing industry include the following:

i) End-of-pipe (full & partial flow)
ii) Flow in a Closed Pipe
iii) Open Channel Flow
iv) Miscellaneous

Several methods are used to measure flow under each of the above conditions. The method chosen depends on several factors, including the required accuracy. Other factors which lead to method selection are range of flow, cost of equipment, ease of operation, and physical limitations such as plant layout and equipment design.

i) Pipe Discharge

Full Flow:

There are a few methods available for measuring full flow at the end of a pipe.

- ***Bucket & Stopwatch***

Often, this is the easiest, most practical, and accurate methods to find flow from a pipe. All that is needed is a graduated "bucket" or other measuring container, a stopwatch, and reasonable care. The collection container can be further divided using a graduated cylinder if it has not been calibrated, or if greater accuracy is required.

This method is limited to smaller pipe sizes and/or low flows, as it may become difficult to collect all the liquid from a large pipe in a specified period.

- ***The "Yardstick" Water Measuring Method***

To approximate the flow rate from a horizontal or inclined pipe, the "yardstick" method may be used. The flow may be approximated by measuring the distance, "X", in inches when the vertical distance from the top of the pipe to the top of the discharging flow is 12

inches. Tables have been generated relating the distance "X" to different pipe diameters, giving a corresponding estimate of flow in U.S. gal/min. Further to this method, a 6" vertical distance may be used in place of 12". Here the estimated U.S. gal/min is multiplied by a factor of 1.4. For results in L/min, multiply the final U.S. gal/min result by 3.785. For details and flow tables, see attached document *Berkeley Pump Company, Table 1).*

Partial Flow:

- ***Bucket & Stopwatch***

The stopwatch method for partial flow in a pipe is the same as that of full flow. However, it is much easier and more convenient to use with partial flow since a liquid can be collected in a given container for a longer period. Often this is the quickest and easiest method to measure partial flow from a pipe, since a container can be positioned properly under the pipe to collect all of the discharge.

- ***"Yardstick" Water Measuring Method***

The yardstick method for full flow in pipes can be expanded to allow for pipes flowing partially full. The method is the same as for full flow, except a correction factor is added. The factor is obtained by dividing "E" (the distance form the top of the inside wall of the pipe to the surface of the flowing water) by "D" (the inside diameter of the pipe). For each value of E/D, a factor has been estimated empirically which is then multiplied by the U.S. gal/min obtained from the full flowing pipe calculation. See attached document *Berkeley Pump Company, Table 2).*

- ***Standpipe Overflow Weir***

Also known as a "California Pipe Method", this method is used to approximate flow rates in a horizontal pipe (see Figure 1). If the pipe is perfectly horizontal, the depth of water in the pipe becomes a function of the flow through the pipe. The following formula can be developed to describe the relationship between flow and pipe:

$$Q = 3250 * (1 - A/d)^{1.88} d^{2.48}$$

where Q = flow (Imp. gal/min)
d = pipe dia. (ft)
A = vertical distance in feet between the upper inside surface of the pipe and the surface of the liquid.

ii) Closed Pipe

- ***Ultrasonic Flow meters***

If a rotameter or other in-line flow measuring device has not been installed in a closed pipe, it may be necessary to employ an external method of measurement. A practical instrument for flow measurement in a closed pipe is the "Doppler" flow meter. It is an ultrasonic flow meter whereby a high frequency pressure wave is beamed across the pipe and is reflected back to a detector by particulate matter moving with the flow. The difference between reflected frequency and fixed transmitted frequency implies the flow rate. The Doppler-type flow meter relies on small particles or impurities in the flow but has also been used successfully on many almost-clean as well as very dirty streams. Because of the velocity profile, accuracy depends on particle concentration and distribution. Accuracy is also influenced by the relative velocity between particles and fluid. Doppler meters have been reported as having repeatability problems because of the minimum required particulate concentration, or varying depth of beam penetration.

iii) Open Channel Flow

- ***Weirs***

The easiest method to measure flow in an open channel is by using a weir. Weirs can easily be custom built to suit many channels and ranges of flow. For very good accuracy under low flow conditions, the "triangular" or "V-notch" weir is often used. They can be designed to measure flows from about one to more than 1000 Imp. gal/min. Other weirs commonly used are rectangular weirs, suited to higher flows, and trapezoidal (or Cipolletti) weirs. Each type has an associated characteristic equation for finding the flow rate through the weir.

Criteria for Selection of Weir

Since open channel flow rates in the metal finishing industry are usually low as compared to large sewer discharges, the preferred design is the "V-notch" thin-plate weir. For reasons related to accuracy and construction, thin-plate weirs are best used for the measurement of small discharges. Broad-crested weirs, triangular-profile weirs and flumes are best used for large discharges.

The range of the V-notch weir is determined by the angle of the notch, α. Commonly used notch angles include 22.5, 45, and 90 degrees. By measuring the head created by the weir, the flow can be calculated by the "Kindsvater-Shen" formula. For the more popular notch angles, tables of head vs flow have been generated in the literature for quick determination of flow rate. Although easy to construct, the weir must be built within certain guidelines for the formula to be valid.

For V-notch weirs, the flow formula can be simplified to the following:

$$Q = 1.42 \tan \alpha / 2h^{5/2}$$

where, Q = flow rate, m^3/s
α = notch angle, in degrees
h = measured head over weir, m
p = height of weir crest to floor of channel, m
B = channel width at weir section, m

This characteristic formula has certain limitations as follows:

- h/p limited to the range 0.1-2.0 for 90° V-notch, and not greater than 3.5 for all other angles within the range of 20-100°;
- p/B limited to 0.1-1.0 for a 90° V-notch, and 0.1-1.5 for other values of α;
- h not less than 0.06 m;
- p not less than 0.09 m

Specifications for use of Thin-Plate V-Notch Weirs

Thin-plate weirs and free overfalls require a sufficient difference between upstream and downstream water levels that will ensure free, fully ventilated flow under conditions of maximum discharge.

V-notch weirs of large size compared with the size of the approach channel should be located in vertical-walled, level-floored rectangular channels. For thin-plate weirs of small size compared with the approach channel, especially if the velocity of approach is negligible, the size and shape of the channel are unimportant.

For weirs of all types, flow in the approach channel should be subcritical, uniform and steady. In short channels and weir boxes, baffles and flow-straighteners may be used to simulate normal velocity distribution.

Sub-critical flow is ensured when:

$$v_{avg} < (g A/B_s)^{0.5}$$

where; v_{avg}, is the average velocity in the approach channel, in m/s
g, is the acceleration due to gravity, in m/s^2
A, is the cross-sectional area of the channel, in m^2

B_s, is the width of the channel at the water surface, in m

The discharge over thin-plate weirs depends on the head on the weir, the size and shape of the discharge area, and an experimentally determined coefficient which considers the head on the weir, the geometrical properties of the weir and approach channel and the dynamical properties of the water.

Thin-plate weirs must be installed vertical and perpendicular to the walls of the channel. The intersection of the weir plate with the walls and floor of the channel should be watertight and firm, and the weir should handle the maximum flow without distortion or damage. The joint between the weir plate and channel can be packed with chemically inert cement or asphalt-type roofing compound.

The approach channel should extend upstream from the weir a distance not less than ten times the width of the nappe at maximum head. The flow in the approach channel must be uniform and steady, with the velocity distribution approximating that in a channel of sufficient length to develop normal flow in a smooth, straight channels. The shape and size of the channel downstream from the weir are of no significance, but the level of the water in the downstream channel should be a sufficient vertical distance below the crest to ensure free, fully ventilated discharges.

The head-measurement section should be located a sufficient distance upstream from the weir to avoid the region of draw down caused by the formation of the nappe. On the other hand, it must be sufficiently close to the weir that the energy loss between the head-measurement section and the weir is negligible. A distance equal to four to five times the maximum head (four to five h_{max}) upstream from the weir should be used. The gauge used should be inserted into a quiet section of the channel away from all disturbances. The zero point of the head measuring device (i.e., dip pole) must be set exactly level with the weir crest.

For flows with suspended material, careful use of thin-plate weirs must be employed since the crest edge may become damaged or worn by the suspended materials. For waters containing excessive solid materials or silt, weirs are not suitable.

The use of a V-notch weir should be avoided where a stream contains floating debris unless a debris trap is installed upstream.

Accuracy

For V-notch weirs with notch angles between 20° and 100°, the uncertainty of the measurement is one to 2% (at 95% confidence level).

Although the use of a weir allows easy measurement of the flow rate, to ensure accurate measurement many design considerations must be

addressed, as summarized in this document. For more detailed information regarding the selection of weirs, and important design criteria, refer to the ISO STANDARDS HANDBOOK, *"Measurement of liquid flow in open channels"*.

- ***Flumes***

An alternative to a weir is the flume. The most common flumes used in flow measurement are the *"Palmer-Bowlus"* and *"Parshall"* flume. The principle of a flume is similar to that of the weir, in that a restriction of flow is set up to create a head. The head can then be used to calculate the flow rate, since head depends on flow.

Velocity/Area Techniques

- ***Current Meters***

Two common types of current meters are the *"Ott"* meter and the *"Gurley"* meter. Current meters accurately measure the velocity of a liquid stream using a specific "propeller" design that has been previously calibrated. The revolutions of the propeller are measured using a counter. The revolutions/time can then be used in a calibration formula, resulting in velocity. Since $Q = v * A$, the flow in the stream can be calculated by multiplying velocity by the cross sectional area of the stream.

Errors may result in measurement of velocity, since each channel or stream may have its own velocity profile. Several points must then be measured to find an "average velocity". Determination of cross sectional area may prove difficult if the sides and/or bottom of the channel is uneven.

One limiting factor of current meters is that they must be submerged in the stream to operate properly. Also, some skill is required in the operation of the current meter to obtain accurate results.

- ***Alternate Velocity/Area Method*** **(Stop Watch Method)**

This method of measuring the flow rate in an open channel is based on the same principle as the current meter, and specifically the relationship between flow rate, stream velocity, and cross-sectional area.

ie. $Q = v * A$

where; Q = flow rate, m^3/s
v = stream velocity, m/s
A = cross-sectional area of stream, m^2

The difference between this method and that of the current meter is that shortcuts can be used in the measurement of the stream velocity. An object floating in the centre of an open channel can be timed over a certain distance. This method should be performed on a straight run where the flow in the channel is uniform. As an approximation of the average flow in the channel, it can be assumed that the surface velocity in the centre of the channel is approximately 1.15 times the average "bulk" velocity (for most channels). The surface velocity should be measured several times to obtain an average value with a reasonable deviation. If the cross sectional area is measured, the flow rate can be calculated using the formula, $Q = v * A$.

This method of flow measurement is not very accurate and should therefore only be used if a more precise technique is not available. It can also be useful in the preliminary assessment of flows to size proper flow monitoring equipment.

iv) Miscellaneous

- ***Flow Estimating using Lithium Salt Dilution***

Background:

Where sewers are inaccessible or the installation of a flow measuring device is not feasible, the dilution method of flow measurement is recommended. If a known concentration of a material is added at a constant rate upstream of the sampling location, the downstream flow rate may be estimated based on the amount of dilution of the material added. This method assumes perfect mixing and therefore requires adequate turbulence in the stream. It also assumes that the material selected for addition does not react with the waste stream.

$$Q_2 = c_1/(c_2 - c_b) \times Q_1$$

where; Q_1 = flow rate of material added, L/min
Q_2 = flow rate at downstream sampling point, L/min
c_1 = concentration of material added, mg/L
c_2 = concentration of material at downstream sampling point, mg/L
c_b = background concentration of material before addition, mg/L

This method is not limited to the type of conduit used, providing the above criteria are met. If a sample downstream of the addition is analyzed for the material, and background levels of the material are analyzed and accounted for, the flow rate downstream may be calculated as follows:

The downstream flow rate can then be calculated by solving for Q_2.

- ***Flow to a Tank***

If a rotameter or other flow measuring device does not exist on the line requiring measurement, and the flow reports to a plating bath, sump, or tank, the change in fluid level can be used to estimate the flow rate. Simply by blocking the effluent from the tank and monitoring the change in level over a specific period, the average volume per unit time (i.e., flow) can be measured. The dimensions of the tank are used to calculate the volume represented by the change in fluid level in the tank. For example, the volume of fluid in a rectangular tank can be calculated as follows:

$$V = L \times W \times H$$

where; V = volume, m^3
L = length of tank, m
W = width of tank, m
H = height of fluid, m

Then, $Q = V/t$ where; Q = flow, L/min
V = volume, L
t = elapsed time, min

A similar calculation can be used for tanks of all shapes and sizes.

Another method of estimating the flow to a tank where the volume of fluid retained in the tank is constant, is to measure the effluent from the tank. This method assumes that *flow rate in = flow rate out*. For example, if the flow rate to a series of counter current rinse tanks is required, and the first rinse tank is bottom-fed, it may be difficult to measure the influent flow. Assuming none of the tanks are leaking and there are no other discharges from the rinse tanks, the overflow from the final counter current rinse may be measured. Since the volume of water retained by the rinse tanks is constant, we are correct if *flow in = flow out*.

APPENDIX B

ESTIMATION OF MASS PLATED ON PARTS IN THE METAL FINISHING INDUSTRY

Draft Method Summary

To complete a material balance on metals used in the metal finishing industry, the mass of metal plated on the part must be known. This is particularly useful in identifying "unaccounted-for losses" of raw materials and provides a measure of utilization efficiency. It is recognized that the mass of metal plated on a part is more complex than shown here, however, if educated estimations are used, it should provide very useful information as well as identifying strengths and weaknesses related to quality control and optimization. The methods, one through four, provide some suggested means of calculating the mass plated on the product, given different circumstances.

METHOD 1. Plated Thickness and Surface Area of Parts Known: (per customer specifications)

Direct Mass Calculation

If the plated thickness of the metal is known, and the surface area of the part is known or can be easily estimated (i.e., measurement with a ruler, etc.), the volume of metal plated on the product can be calculated, since *volume = surface area * thickness*. Using the density of the metal, the mass plated on the product can be calculated:

$$m = V * \rho$$

where; m = mass of metal plated, g
V = volume, cm^3
ρ = density of metal plated, g/cm^3

METHOD 2. Plated Thickness known, Surface Area of part unknown:

Volume Displacement Method for Surface Area Calculation

To estimate the mass plated on metal parts, two parameters must be known. First, the surface area of the part to be plated must be known. If the part to be plated is simple in shape, an estimate of area can be made by simple measurements with a ruler. If the part is very complex, the area can be estimated by a two-step process:

i) Measure the *volume* of the part by water displacement in a graduated cylinder. It may be necessary to use several parts to get a reasonable displacement of water in the container. If more than one part is used, the volume read must be divided by the number of parts used to give the volume/part.

ii) The *thickness* of the raw, unplated part must be measured. This is done using callipers or a micrometer. If the part is of uniform thickness, a few measurements can be averaged to give the thickness. If the thickness of the part varies, some judgement must be used to come up with an average thickness of

the part.

Having completed steps i) and ii), the surface area of the part can be estimated by dividing the volume from i) by the thickness from ii).

$$ie.\ A_s = V / t_r$$

where; A_s = surface area of part, cm^2
V = volume, cm^3
t_r = avg thickness of raw part, cm

Secondly, the thickness of each the metals plated on the part must be known. The estimate of plated thickness can often be a difficult task, as thicknesses usually vary between the front and back of the parts. The positioning of the part on the rack will also influence the amount of metal plated on the part. An "educated estimate" of the plating thickness can usually be found in company records, plating specifications, or through experience with the specific process after giving consideration to the inherent interferences in the estimate.

Knowing the average thickness of metal plated and the surface area of the part, the mass of metal plated can easily be calculated:

$$m = A_s * t_k * \rho$$

where; m = mass, g
t_k = avg. thickness of metal plated, cm

METHOD 3. Plated Thickness & Surface Area unknown:

Direct Mass Measurement

For small parts, it may be possible to measure the plated mass directly using an analytical balance for estimating purposes.

If more than one metal is plated on a product (i.e., copper/nickel/chrome), the relative masses can be measured progressively.

METHOD 4. Plated Thickness & Surface Area unknown, Current & Contact time known:

Faraday's Law

Faraday's Law, as it applies to metal finishing, says that the passage of 96,500 amperes of electric current for one second will transfer one gram equivalent of metal. Therefore;

$$\#eq = A*t / 96{,}500$$

where; #eq = no. of equivalents of metal transferred
A = Current, DC Amps
t = plating time, sec

From # equivalents of metal plated, the mass plated can be calculated as follows:

$$m = \#eq\ plated * g\ eq.wt.$$

where; m = mass, g
g eq.wt.= gram equivalent weight

Finally,

$$m = A * t * g\ eq.wt. / 96{,}500$$

Note, this method assumes 100% cathode efficiency unless an efficiency factor is considered in the calculation. Table 1 provides an example of required information for this method from a copper/nickel/chrome plating facility.

Table 1.

BATH	PLATING ION	FORMULA WT.	g eq.wt.	ρ, g/cm^3 @20C
Acid Copper	Cu^{+2}	63.546	31.773	8.92
Cyanide Copper	Cu^{+1}	63.546	63.546	8.92
Nickel	Ni^{+2}	58.70	29.35	8.90
Chrome	Cr^{+6}	51.996	8.666	7.2

Therefore, knowing the number of parts plated in a given period, the mass in kg of metal plated can be approximated (Note: If the period is large, i.e., one year, caution must be exercised with respect to variability of the physical part and therefore the plated surface area.) This quantity is vital during the mass balance phase of the program and as mentioned, can be useful in measuring the utilization efficiency of various metals within the facility.

As an aside, if the average thickness of metal plated is unknown, it can be estimated following this method if the surface area, A_s of the part is known, as well as the mass of metal plated since,

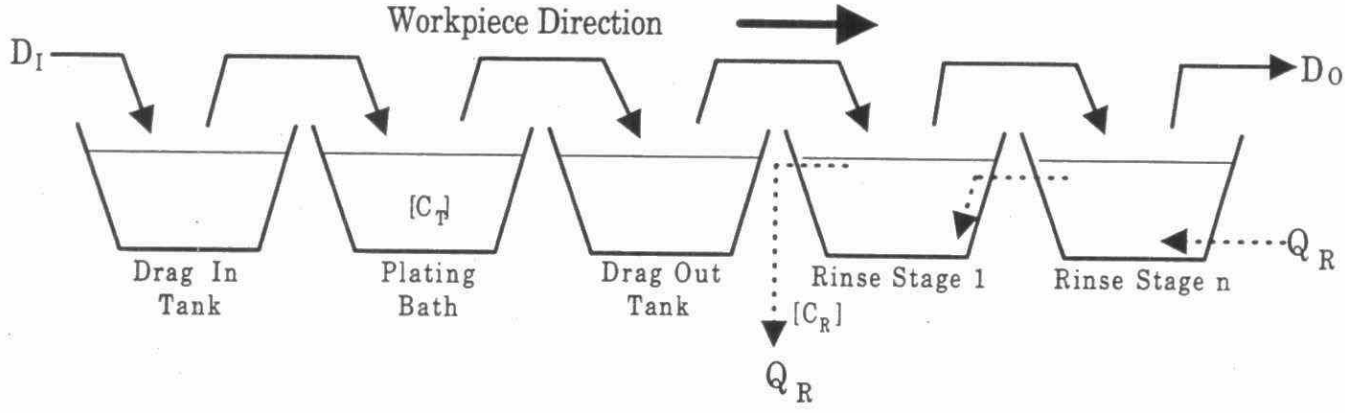
$V = A_s * t_k$, and $V = m / \rho$.

i.e., $t_k = m / \rho * A_s$

ESTIMATION OF NUMBER OF COUNTER CURRENT RINSE STATIONS

The formulae show the relationship between drag-out volumes, the number of rinse tanks and rinse water flow in a counter current rinse system.

A typical counter current rinsing pattern:



To calculate the fresh water flow to achieve a given rinse water effluent concentration, the following formula can be used:

$$Q_R = D_I \left(\frac{C_T}{C_R}\right)^{\frac{1}{n}}$$

Q_R = rinse water flow rate (L/min)
D_I = drag-out rate (L/min)
C_T = concentration of metal in plating bath (mg/L)
C_R = desired concentration of metal in rinse water (mg/L)
n = number of counter current rinse tanks

When the plating bath concentration and the allowable rinse water concentration are known, then the concentration ratio, R_C, can be calculated as:

$$R_C = \frac{C_T}{C_R}, \quad then: \quad Q_R = D_I \, (R_C)^{\frac{1}{n}}$$

Note, these formulae apply to a counter current rinse system, where all rinse tanks are of equal size.

For example, if the drag-out flow rate (D_I) is 1 L/min, the nickel concentration in the plating bath is 10,000 mg/L, and the final nickel concentration in the rinse water must be 1 mg/L, then R_C = 10,000 and the rinse water flow rate (Q_R) required to maintain rinsing efficiency can be estimated for one to n rinse tanks in series as follows:

$Q_R = 1 \cdot (10{,}000)^{1/n}$

then, for n = 1; Q_R = 10,000 L/min
n = 2; Q_R = 100 L/min
n = 3; Q_R = 21.5 L/min, etc.

If the dilution factor required is less, say 1000, (perhaps because you have a low concentration plating solution), then the number of tanks required will decrease in number, or, for the same number of tanks, the flow rate of rinse water required will be lower.

The U.S. EPA [1994] has reported another formula for the required rinse water flow rate. For most situations, the differences in the formulas are small. The EPA version is as follows:

$$Q_R = D_I \cdot [(R_C)^{\frac{1}{n}} + \frac{1}{n}]$$

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APPENDIX C: METRICS

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Initiatives to promote pollution prevention have been undertaken in government and industry. One of the greatest challenges to strengthening and expanding these efforts is developing measures to evaluate alternatives and assess progress in reducing or minimizing waste generation and/or release. Throughout this manual pollution prevention has usually been measured as amount of waste reduced or eliminated (usually as kgs or tonnes) per project or per year. This measure is very good for evaluating alternatives. However, problems arise when this measure is used to evaluate progress year over year since waste creation and/or release is generally related to production rate.

Most pollution prevention specialists agree that the measure used to assess pollution prevention progress should be normalized to the level of industrial activity. However, which production index should be used, as the choice of production index may influence the apparent environmental performance? To explore this issue, toxic release inventory performance data in the US was analyzed using five indicators of production activity (wages of production employees, value added in the facility, value of shipments, number of units produced and number of production employees). With few exceptions, the choice of production index had little bearing on the relative performance. Facilities should use a production index which best reflects changes in their firm's business activity. The index should have a primary influence on the quantity of chemicals used, recycled, treated or disposed and the availability of historical data.

APPENDIX D: SAMPLE FORMS

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Step 1. Establish Program **Form 1 - Part A**

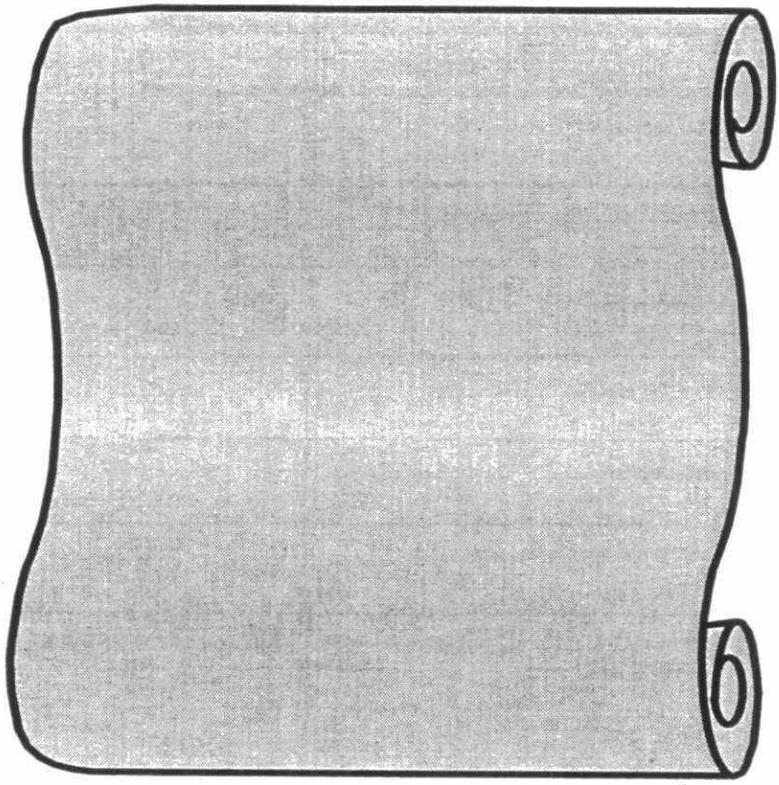
_____ Pollution Prevention Team

Team Member	Company Position	Responsibility
	(Management)	
	(Production Representatives)	
	(Plant Operations)	
	(Environmental Officer)	
	(Administration)	
	(Lab & Quality Assurance)	
(Others as needed:)	(Office and plant staff, safety and health officer, others)	(Information collection and input into program as required)
	("Advisors")	("Unbiased" facilitators of Pollution Prevention program)

(Environmental Mission Statement and General Objectives and Priorities in Part B on reverse)

Who: **Representatives from all levels of the company hierarchy and at least one member representing company management for the company P2 Team.**
What: **P2 Team provides guidance to company employees on pollution prevention in the facility.**
Why: **Establishing a P2 Team, with management participation, ensures that the company endorses the program. A multi-disciplinary P2 Team ensures participation from all company levels and includes all employees which is consistent with the TQM philosophy.**
When: **The P2 Team should be formed as soon as possible, after management committment has been confirmed.**

Environmental Mission Statement



General Objectives and Priorities

-
-
-
-
-
-
-
-

Written "Environmental Mission Statement" and company Objectives and Priorities will establish the initial focus of the P2 Team. The mission statement must reflect the company's policy towards its clients, employees and corporate responsibilities. The objectives and priorities must compliment the mission statement and should specify the overall needs of the Pollution Prevention program. Each P2 Team member, in the initial meeting should offer an opinion of the objectives for the program. Then through consensus building, the final list of general objectives and priorities will be set. The Mission Statement and program objectives should be prominently displayed so that all employees can be advised of the Pollution Prevention Program expectations.

Step 1. Establish Program **Form 2**

Pollution Prevention Planning Schedule

Mtg	TASK	Month															
		Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Introduce concepts																	
	Get manager commitment																	
2	Establish team, schedule																	
	Do site inspection																	
3	Assess available data																	
	Review procedures, forms																	
	Collect existing information																	
4	Review, assess collected data																	
	Identify, implement BMP's																	
	Identify missing information																	
4/5	Introduce detailed data collection																	
	Collect, assess detailed data																	
5	Progress meeting, review BMPs practices																	
	TASK																	
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
6	Review data																	
	Prioritize waste streams																	
	Set priorities, identify concerns																	
7	Evaluate Pollution Prevention options																	
	Schedule and implement favourable option																	
	Measure and report																	
8	Prepare Toxics Reduction Plan																	
	Report to Task Force																	

P2 Team members must agree on a realistic timetable for the Pollution Prevention Program that offers achievable milestones. The milestones must be set within a reasonable time frame; neither too short that will result in discouragement and frustration in not meeting goals, nor too long a time period that will result in employees losing interest in the process. The schedule must be set to sustain interest in the program. The P2 Team will develop the timetable at the program initiation meeting and should regularly update and modify the schedule in progress. The simplest method is to insert months into the appropriate boxes and "X"s or dates into the schedule boxes.

Environmental Management CHECKLIST for the Metal Finishing Industry

I. WASTE MANAGEMENT PRACTICES

A) Health & Safety Issues (7 items) 2
B) Inventory Management (7 items) 2
C) Packaging Management (5 items) 3
D) Storage Management (10 items) 3
E) Waste Segregation (10 items) 4
F) Consolidation/Reuse/Recovery (12 items) 4
G) Preventative Maintenance (7 items) 5
H) Spill Response (14 items) 6
I) Operational Practices (37 items) 7

Answer all questions with either a yes/no response, or rate from 0-4 as shown on the following pages.

Who: Team
What/Why: Self assessment exercise on company's environmental practices
Where/When: Do at the initial Team meeting; review and revise after site inspection
How: Complete questionnaire with yes/no response or 1 to 4 rating

---

The 8 page checklist is easy to complete and it introduces the Team to all aspects of environmental management. The checklist helps the Team identify acceptable practices and potential initial waste concerns and introduces possible solutions to these concerns. Prior to conducting the site inspection, the Team should take about 1 to 2 hours and review the checklist and complete all possible questions to the best of the Team's abilities. Following the tour, the Team should review the checklist and modify and complete the Checklist based on the additional knowledge and insights gained from the site inspection.

The checklist is a paper exercise designed to identify and evaluate current operations and to ensure that "Best Management Practices" (BMPs) are being followed. Completion of this form should be guided by those team members who are familiar with shipping & receiving, material handling, waste management practices, and contingency planning. All team members should contribute by questioning any rating to which a team member is unsure of the response.

I. WASTE MANAGEMENT PRACTICES

A) Health & Safety Issues[1]

A1. Do you know what WHMIS is? A1. ☐ Y/N

A2. Have you obtained a current MSDS and a label for every controlled product or chemical in the workplace? A2. ☐ Y/N

A3. Do you have the most current version of your chemical inventory and MSDS's? A3. ☐ Y/N

A4. Have you made your chemical inventory and MSDS's available in the workplace so that your workers can view them? A4. ☐ Y/N

A5. Have you labelled every controlled product? A5. ☐ Y/N

A6. Have you trained your employees to ensure that they are familiar with the contents of WHMIS, MSDS's and labels? A6. ☐ Y/N

A7. Do your employees understand the procedures for safe use, storage, handling and disposal of each controlled product, and how to respond in an emergency situation? A7. ☐ Y/N

B) Inventory Management

B1. Do you have an inventory system for raw materials? B1. ☐ Y/N

Type of Inventory (ie. card system, computer, etc.):

B2. Have you identified chemicals or products which are designated as controlled products under the federal Hazardous Product Act and/or your provincial regulations? B2. ☐ Y/N

B3. How often is an inventory performed to identify an excess accumulation of materials? B3. ☐ (0-4)

B4. Are inventory controls used to assure that chemicals in a container are completely used prior to opening a new container? B4. ☐ (0-4)

B5. Do you try to order smaller containers of infrequently used materials to avoid disposing of large quantities of unused obsolete materials? B5. ☐ (0-4)

---

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

B6. Have you tried to order larger containers of frequently used materials to reduce the number of small containers that must be cleaned and disposed of? B6. ☐ (0-4)

B7. Do you have an inventory system for wastes? B7. ☐ Y/N

C) Packaging Management[1]

C1. Are employees trained to safely handle the types of drums & packages received? C1. ☐ Y/N

C2. Are drums, packages, and containers inspected for damage before being accepted? C2. ☐ (0-4)
Describe handling procedures for damaged items:

C3. Are empty containers rinsed so they can be recycled as a nonhazardous solid waste? C3. ☐ (0-4)

C4. Are container rinse solutions used for process bath additions? C4. ☐ (0-4)

C5. Are empty containers returned to the supplier? C5. ☐ (0-4)

D) Storage Management

D1. Are personnel trained to ensure proper handling and storage of materials? D1. ☐ Y/N

D2. Does the company use a first-in first-out material use policy to prevent deterioration? D2. ☐ (0-4)

D3. Does the company minimize inventory to prevent degradation due to long storage? D3. ☐ (0-4)

D4. Are stored items protected from damage, contamination, or exposure to rain and heat? D4. ☐ (0-4)

D5. Does the layout of the facility result in heavy traffic through the raw material storage area? (Heavy traffic increases the potential for contaminating raw materials with dirt or dust and for causing spilled materials to become dispersed throughout the facility.) D5. ☐ (0-4)

D6. Can traffic through the storage area be reduced to prevent accidents? D6. ☐ (0-4)

D7. Do chemical and waste storage areas have spill control curbing? D7. ☐ (0-4)

---

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

D8. Are spill cleanup equipment and sorbents readily accessible to chemical and/or waste storage areas? D8. ☐ (0-4)

D9. Do you keep your hazardous wastes, such as solvent, or cyanide-containing sludge in compatible drums and stored in a dyked area? D9. ☐ (0-4)

D10. Are waste drums or piles on an impermeable base compatible with the waste? D10. ☐ (0-4)

E) Waste Segregation[1]

Segregation of wastes reduces the amount of unknown material and improves prospects for reuse.

E1. Do you segregate cyanide waste streams from non-cyanide waste streams? E1. ☐ (0-4)

E2. Do you mix spent pickling solution and spent cyanide-based plating solution? E2. ☐ (0-4)

E3. Do you segregate chelate-containing waste streams from non-chelate containing wastes? E3. ☐ (0-4)

E4. Are chromium waste streams segregated? E4. ☐ (0-4)

E5. Are spent processing baths segregated from rinsewaters? E5. ☐ (0-4)

E6. Are different solvent wastes from equipment cleanup segregated? E6. ☐ (0-4)

E7. Do you segregate solvent-based wastes from water-based wastes? E7. ☐ (0-4)

E8. Is there a floor wash collection system to collect spills and drag-out and to direct them to proper treatment? E8. ☐ (0-4)

E9. Are all empty bags, packages, and containers that contain hazardous materials segregated from those that contain nonhazardous wastes? E9. ☐ (0-4)
Describe the method currently used to dispose of this waste:

E10. Are waste streams not needing treatment sent to treatment? E10. ☐ (0-4)

F) Consolidation/Reuse/Recovery

F1. Do you return excess (unused) solutions to the manufacturer for recycling? F1. ☐ (0-4)

F2. Do you recycle materials on site? F2. ☐ (0-4)

---

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

F3. Are rinse water streams recycled? F3. ☐ (0-4)

F4. Are the metals in spent process baths reclaimed? F4. ☐ (0-4)

F5. Are spent process baths used for other beneficial purposes? F5. ☐ (0-4)

F6. Is spent cleaning solvent reused as thinner or initial wash? F6. ☐ (0-4)

F7. Have you contacted other platers to see if they want your solutions for recycling? F7. ☐ (0-4)

F8. Have you contacted waste exchange services or brokerage firms regarding wastes? F8. ☐ Y/N

F9. Are many different solvents used for cleaning? F9. ☐ Y/N

F10. Has on-site distillation of spent solvent ever been attempted? (On-site recovery of solvents by distillation is cost effective for as little as 8 gallons of solvent per day.) F10. ☐ Y/N

If yes, is distillation still being performed? If no, explain: F10. ☐ Y/N

F11. If too many small-volume solvent waste streams are generated to justify on-site distillation, can the solvent used for equipment cleaning be standardized? F11. ☐ Y/N

F12. Discuss other wastes that you are currently recycling and by which means:

G) <u>Preventative Maintenance</u>[1]

G1. Do you plan and schedule most of your maintenance? G1. ☐ (0-4)

G2. Are dropped parts removed from tanks after each shift? G2. ☐ (0-4)

G3. Do you also clean the tank bus bars and contacts? G3. ☐ (0-4)

G4. Does the company have a formal inspection program? G4. ☐ (0-4)

G5. How often are inspections of the chemical storage area, process areas, and waste treatment areas conducted? G5. ☐ (0-4)

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

G6. Are identified malfunctions followed up to ensure that they are corrected? G6. ☐ (0-4)

G7. Are inspections logged and are logs maintained in permanent records? G7. ☐ (0-4)

H) Spill Response[1]

H1. Has a spill contingency plan been developed? H1. ☐ Y/N

H2. Has the plan been tested? H2. ☐ Y/N

H3. Is the plan updated annually? H3. ☐ Y/N

H4. Have you consulted your regulatory agencies regarding your contingency plan? H4. ☐ Y/N

H5. Are employees properly trained in handling of spilled raw materials? H5. ☐ Y/N

H6. Does the plant generate waste due to spills during material handling or storage? If yes, what is the frequency of these spills. H6. ☐ Y/N

H7. Are measures employed to prevent the spillage of liquids being dispensed? H7. ☐ Y/N

H8. Is spill containment provided to minimize the amount of cleanup materials used to contain and clean up spills? H8. ☐ Y/N

H9. Describe spill containment used in material storage areas.

H10. Are sorbent materials available to soak up chemical spills safely and efficiently? H10. ☐ Y/N

H11. When a spill occurs in the facility, what cleanup methods are employed (wet or dry)?

H12. Describe the manner in which the resulting wastes are handled.

H13. Are leaks in equipment, storage vessels and piping corrected immediately? H13. ☐ Y/N

H14. Are records of spills kept? H14. ☐ Y/N

[1]Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

I) Operational Practices[1]

I1.	Do you recycle process water?	I1. ☐ (0-4)
I2.	Do you recycle non-contact cooling water?	I2. ☐ (0-4)
I3.	Do you use deionized water for process water &/or baths?	I3. ☐ (0-4)
I4.	Is the fresh water feed shut off when a plating line is not in use?	I4. ☐ (0-4)
I5.	Do you practice reactive rinsing?	I5. ☐ (0-4)
I6.	Do you practice countercurrent rinsing?	I6. ☐ (0-4)
I7.	Is fresh water feed introduced into the bottom of rinse tanks?	I7. ☐ (0-4)
I8.	Has (air) agitation been applied to all rinse tanks and cleaner tanks?	I8. ☐ (0-4)
I9.	Do you use constant flow regulators for your rinse tanks?	I9. ☐ (0-4)
I10.	Do you use rinse water as a make-up liquid for evaporative losses from a process tank?	I10. ☐ (0-4)
I11.	Do you use a warm water rinse after an electro-cleaning or alkaline-cleaning stage?	I11. ☐ (0-4)
I12.	Do you monitor drag-out volumes for the various types of products that are plated?	I12. ☐ (0-4)
I13.	Do you use drag-in/drag-out tanks?	I13. ☐ (0-4)
I14.	Do you maintain heated baths (eg. copper, zinc and nickel plating baths) at elevated temperature during non-normal operating hours to induce additional water evaporation?	I14. ☐ (0-4)
I15.	Is the heated plating bath operated at temperature close to the upper limits of the allowable operating temperature ranges?	I15. ☐ (0-4)

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

I) Operational Practices (continued)[1]

I16. Do you tumble or rotate the parts (barrels) after withdrawal? I16. ☐ (0-4)

I17. Do you use a drip board between a plating bath and a rinse tank? I17. ☐ (0-4)

I18. Do you use the lowest possible chemical concentrations at which the process bath can operate? I18. ☐ (0-4)

I19. Do you drill out all the barrel holes to return them to their original size? I19. ☐ (0-4)

I20. Do you routinely strip or clean racks to maintain peak plating performance? I20. ☐ (0-4)

I21. Are there production incentives for employees? I21. ☐ (0-4)

I22. Do you drain barrels or racks of plated parts over the floor? I22. ☐ (0-4)

I23. Are the sand/grit blasting, polishing, grinding and buffering operations separated from the plating room to prevent particulates from getting into the process tanks? I23. ☐ (0-4)

I24. Do you regularly monitor bath solution concentrations and routinely make adjustments?
If so, how frequently? I24. ☐ (0-4)

I25. Do you use chemical baths for stripping? I25. ☐ (0-4)

I26. Do you use an electrolytic stripper rather than a chemical bath for stripping? I26. ☐ (0-4)

I27. Do you use solvent based cleaners? I27. ☐ (0-4)

I28. Have you switched from solvent based to aqueous based cleaners? I28. ☐ (0-4)

I29. Do any of the process solutions contain chelating compounds? I29. ☐ (0-4)

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

I) Operational Practices (continued)[1]

I30. Do you use recovery/recycle treatment technologies for environmental management? I30. ☐ (0-4)

I31. Do you have atmospheric evaporators for recycling drag-out? I31. ☐ (0-4)

I32. Do you monitor air quality in the facility? I32. ☐ (0-4)

I33. Do you monitor wastewater quality from the facility? I33. ☐ (0-4)

I34. Do you monitor waste solids disposal? I34. ☐ (0-4)

I35. Do you have a solid wastes segregation program? I35. ☐ (0-4)

I36. Are sludges and soils in rinse tanks removed periodically? I36. ☐ (0-4)

I37. Does the company generate spent process bath wastes that are not treated on site because of concerns about upsetting the treatment process? I37. ☐ (0-4)

Additional Comments:

[1] Rating: 0 = not done; 1 = seldom done; 2 = sometimes done; 3 = usually done; 4 = always done

Step 2. Do Preliminary Assessment **Form 4**

Site Inspection Form

(page ___ of ___)

Tour Date: _____

Participants: _____ _____

_____ _____

_____ _____

==========

#	Observation	Recommendation

Who: P2 Team members during Site Inspection tour
What: Identify all observations ONLY, during walk about. After the tour, P2 Team members should meet to discuss and suggest or list possible recommendations to resolve observed concerns.
Why: To identify observations that are housekeeping concerns and that can be resolved by "Best Management Practices". The other observations that relate to waste sources should be added to an inventory of potential wastes for the facility.
Where/When: Complete during Site Inspection
How: All members should record observations during the tour, then consolidate findings of the P2 Team at the meeting following the Site Inspection.

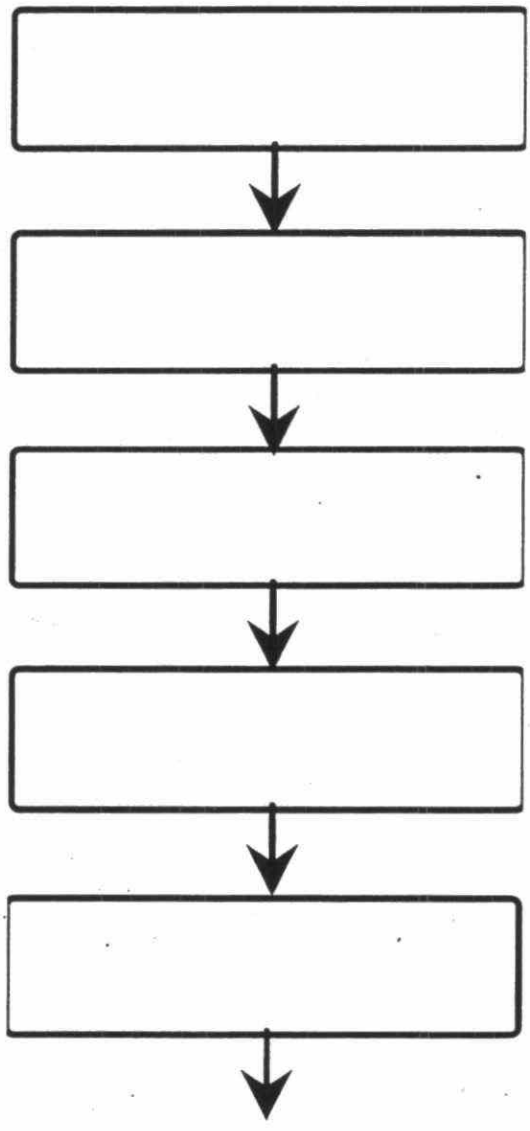
cont'd attached page(s) # ___ to ___

#	Observation	Recommendation

Step 2. Do Preliminary Assessment **Form 5**

Generic Process Diagram(page____ of ____)

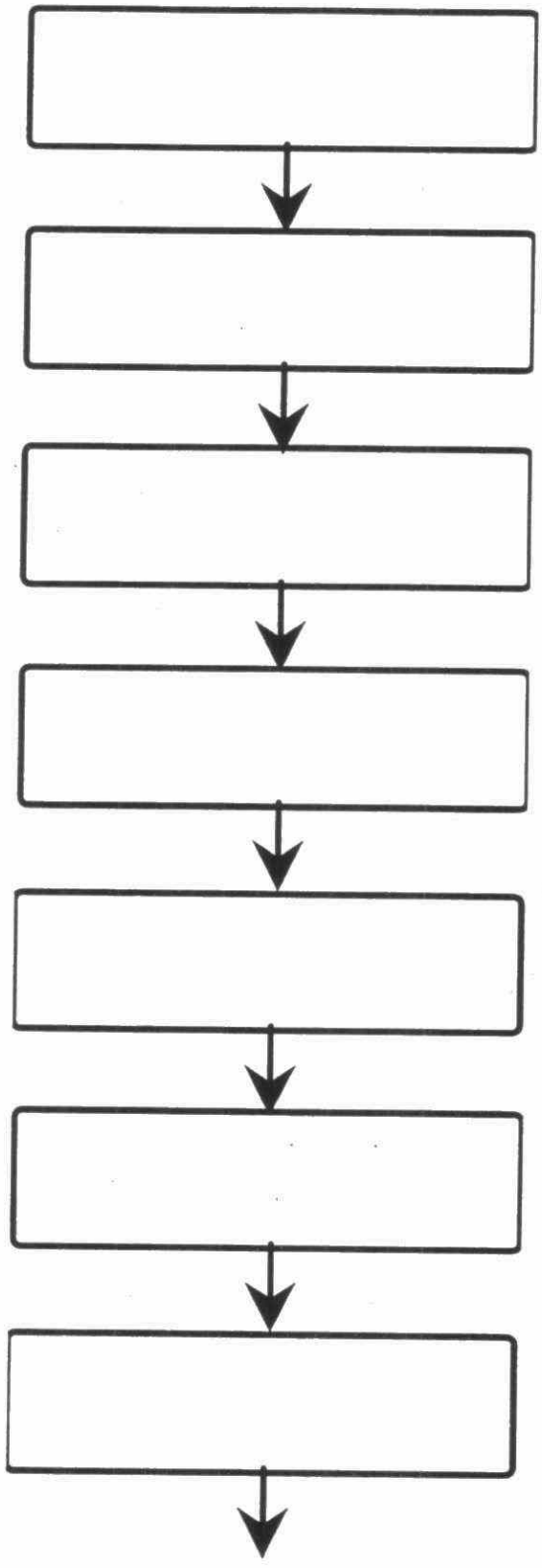
Inputs **Outputs**



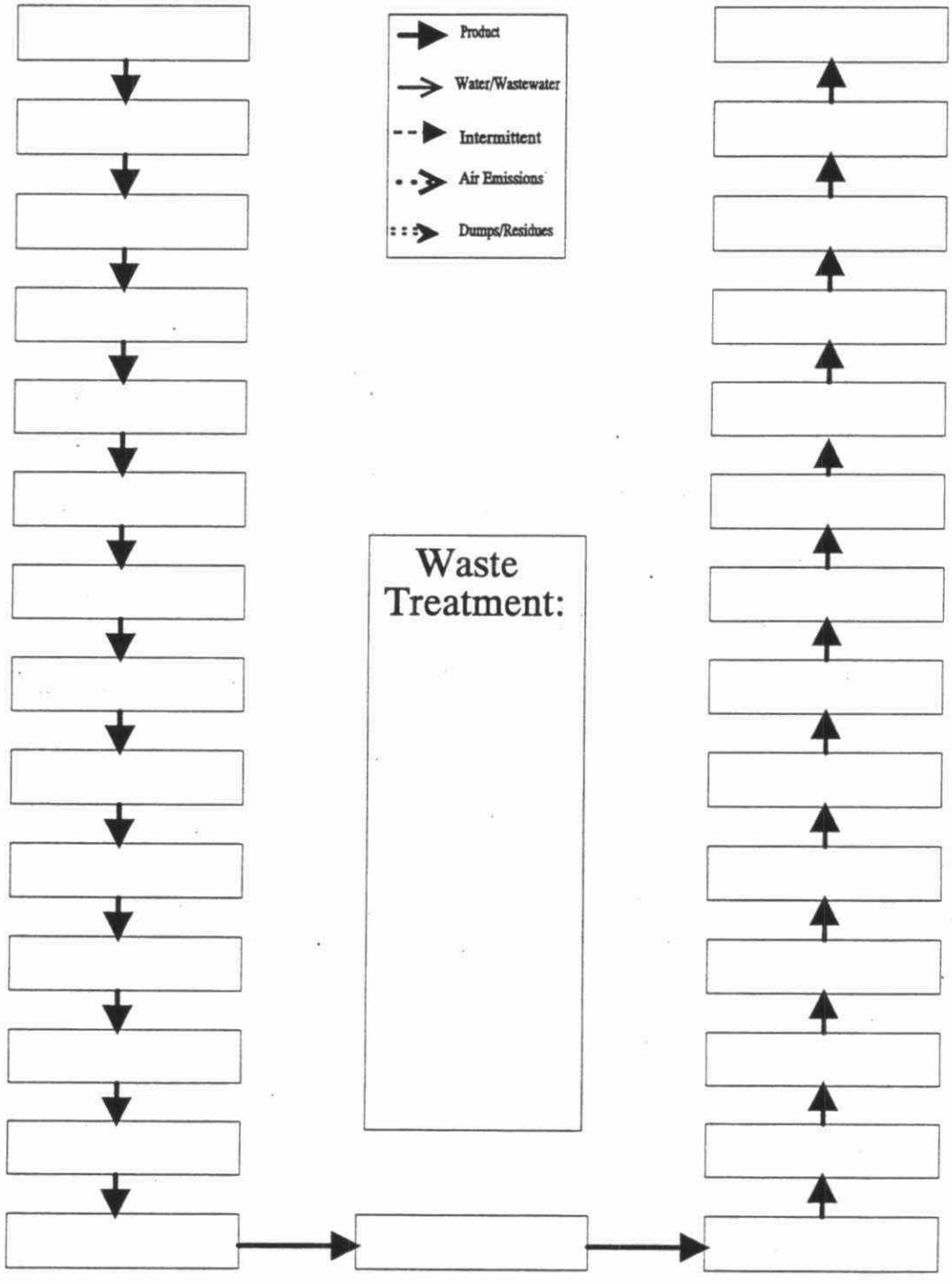
Who: P2 Team members during Site Inspection tour (can be completed after tour)
What: Identify all inputs/outputs to identify inefficiencies of a process by process basis
Why: Developing flowsheet aids team in understanding of production processes and possible wastes
Where/When: Collect information during Site Inspection to ensure all necessary data is collected
How: Use boxes to list unit operations and identify all inputs/outputs from each operation in the adjacent columns

Inputs

Outputs



Generic Process Flowsheet



Who: P2 Team
What: Identify specific unit operations and multi-media waste streams
Why: Developing flowsheet aids team in understanding of production processes and possible wastes
Where/When: Do before or during Site Inspection to ensure all necessary information is collected
How: Enter each operation in the boxes in order of production, identifying all potential wastes

Step 2. Do Preliminary Assessment & Step 3. Prioritize Waste Sources

Form 7

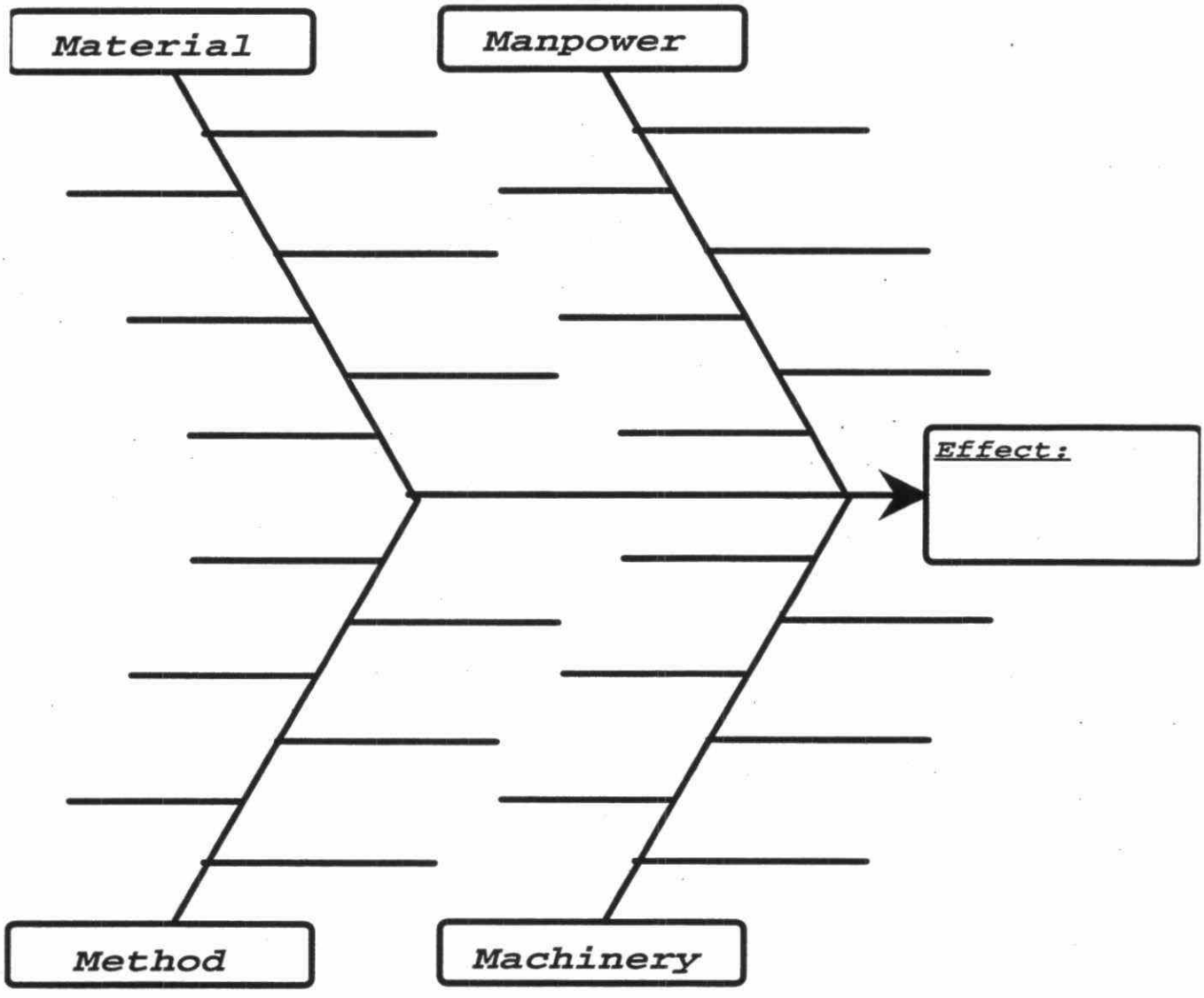
Step 2 - Preliminary Assessment & Waste Identification				Step 3 - Rating Using Three Primary Impact Criteria				
PLANT AREA:		Fate (Where the waste is going)	Quantity/year Note units kg/y lb/y L/y gal/y	Weighting 1= low; 2= med; 3= high	Fate Rating 1-10 (see Table 3-3)	Quantity Rating 1-10 (see Table 3-3)	Toxicity See Appendix B for values	TOTAL
ID # Area-Waste	Waste Identification							

Step 3. Prioritize Waste Sources Form 8

Step 3 - Waste Source Prioritization - Short Listing		Impact Criteria						Changeability Criteria				
ID #		Worker Health & Safety Rating 1-10 (see Table 3-3)	Cost of Lost Raw Materials Rating 1-10 (see Table 3-3)	Cost to Manage Waste Rating 1-10 (see Table 3-3)	Regulatory Compliance Rating 1-10 (see Table 3-3)	Difficulty in Control Rating 1-10 (see Table 3-3)	Environmental Impact Rating 1-10 (see Table 3-3)	Time to Reduce/ Eliminate Waste Rating 1-10 (see Table 3-4)	Potential Pollution Reduction Rating 1-10 (see Table 3-4)	Cost of Change Rating 1-10 (see Table 3-4)	Impact on Production Rating 1-10 (see Table 3-4)	TOTAL
	Weighting: 1= low; 2= med; 3= high											
Area-Waste	Waste Identification	Rating										

 Form 9

Options/Concerns Analysis Chart



Step 4. Determine Root **Form 10**

Cause/Effect Analysis Table

Option or Concern: _____

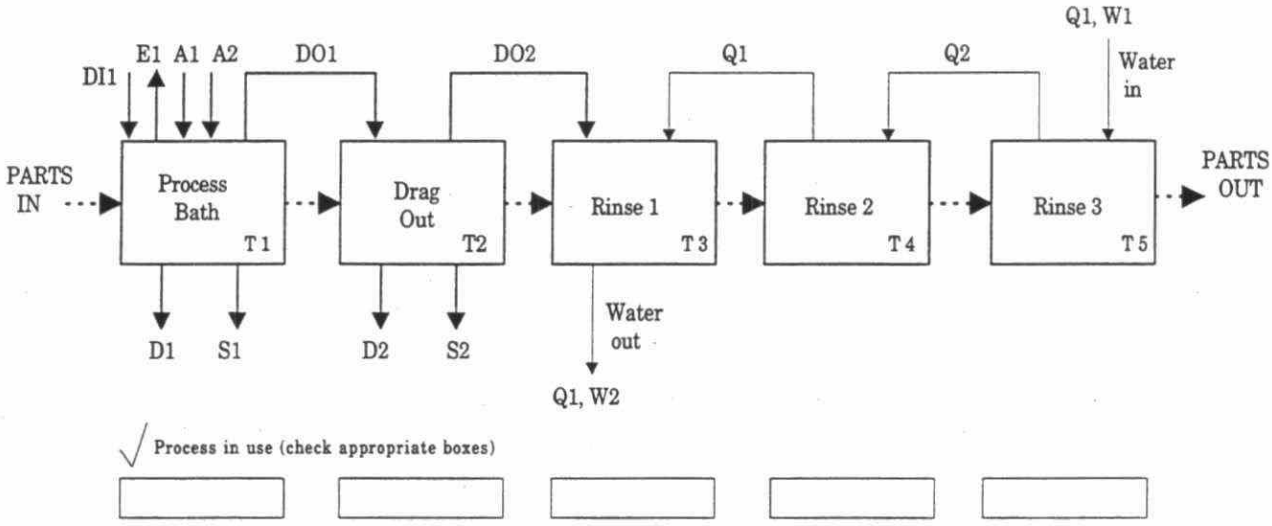
Item No.	Category[1]	Description	Criteria Score[2] 5=high 1=low	Multi-Vote (6 votes/member)					
									Tot

The "fishbone" diagram (Form 9) is useful in identifying the causes of a particular waste concern. The *manpower, methodology, materials, machinery,* and *miscellaneous* categories may assist in isolating different causes. The form should be completed by team members familiar with the specific waste concern. Be sure to identify "root causes" of the problem as opposed to the "symptoms" that are present. The team then selects the root causes which they feel contribute most significantly to the waste using Form 10.

Step 4. Determine Root Causes **Form 11**

Detailed Data Collection Form

Process Description: _____



T = Tank DI = Drag in E = Emissions, air
S = Sludge DO = Drag out A = Additions (make-up)
D = Dump, batch Q = Flow rate W = Water/Wastewater

OPERATIONAL DATA

Tank	Volume, (L)	Temp, (°C)	Dump frequency	Make-ups, (kg/d)		
T1						
T2						
T3						
T4						
T5						

CHARACTERIZATION DATA

I.D.	Description	Volume, (L)	Parameter Concentration, (mg/L)			
DI1						
D1						
D2						
S1						
S2						
DO1						
DO2						
W1						
W2						
Q1						

Who: Team, operators/production staff
What: Collect detailed process information
Why: Data to be used to complete material balances and quantify primary causes of waste source(s)
Where/When: Collect detailed data for only those priority waste sources already identified
How: Develop monitoring/sampling program and establish timeframe. Collect detailed data on log sheets as necessary. Note, tables may have to be modified for specific process being evaluated.

It is very difficult to construct a generic detailed data collection form since processes can vary so widely. However, the sample flow diagram and associated tables shown in this Form should provide a suitable template for the type of data that is useful to collect during a detailed sampling/monitoring program. All material inputs/outputs, flow rates, and production rates should be documented during the period of detailed process evaluation. Waste streams such as plating rinsewaters should be analyzed for suitable parameters in order to provide mass loading information. The data collected should be used to conduct a material balance around each process being evaluated.

Step 4. Determine Root **Form 12**

Materials Balance Table

(page ___ of ___)

TIME FRAME: *1 year*

material	mass input	mass on product	mass in sludge	mass in wastewater	mass in air emissions	total wastes	total mass output	unaccounted-for losses
	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]
	A	B	C	D	E	F=C+D+E	G=B+F	A-G

Who: Team, operators/production staff from the specific process area

What: Conduct material balance on metal or component to be tracked

Why: A material balance clearly identifies/confirms the significance of each waste stream. Quantifying these losses enables a cost to be associated with the waste which is directly attributable. This also provides baseline data necessary for measuring the success from implementing a P2 option (ie. useful in payback calculations, etc.)

Where/When:
The material balance should be completed after all pertinent process data has been collected.

How: Select a timeframe (ie. 1 year) and enter the measured losses in kg/yr in the table

---

It may be difficult to quantify certain metal pathways, especially the mass of metal plated on parts and/or the mass lost to air emissions. For these areas, the difficulty in quantifying is recognized, however "*best approximations*" may be used based on existing data. Otherwise the particular area should be grouped with "unaccounted-for losses".

Step 4. Determine Root Causes **Form 13**

Summary of Potential Waste Sources

Timeframe:
WASTE IDENTIFICATION:

Primary Contaminant:
Volume:

Conc.:
Mass:

Waste Sources	Volume, (L)	Conc., (mg/L)	Mass, (mg)
Total Waste Output			

Who: Team
What: Summary of sources contributing to a waste
Why: Clearly summarizes the quantity of each waste source for a particular waste concern
Where/When: May be useful after all data has been collected.
How: Complete table as shown. "Mass" can be calculated from "Volume" x "Concentration"

Step 5. Generate and Evaluate **Form 14**

Priortization of Pollution Prevention Options

Waste Source: _____ Date: _____

	Criteria				
Rating: 0 = no importance 1 = low importance 2 = somewhat important 3 = moderate importance 4 = important 5 = very important					
Weighting[Note 1]					**Total**
Waste Source	**Rating** (include "+" or "-" as appropriate				

Note 1: Weighting - 1 = low; 2 = medium; 3 = high

Examples of **Criteria**:

- Waste reduction potential
- Worker health and safety
- Impact on product quality
- Cost of implementation
- Utility requirements
- Effect on productivity
- Cost savings potential
- Product/process compatibility
- Pysical space requirements
- Production interruptions (for implementation and operation)
- Labour requirements (implementation, operation, engineering)

Who: P2 Team
What: Prioritizing P2 options
Why: To select most favourable and economical pollution prevention alternative
Where/When: After all data has been collected and P2 alternatives have been resourced, the prioritization form (Form 14) should be used to compare alternatives.
How: Select suitable criteria and enter on Form 14. Apply weighting factor to criteria if you wish to bias one or more criteria relative to the others (eg. if "*Health & Safety*" was deemed more important than "*Waste Reduction Potential*"). List the P2 alternatives and score them under each criteria from 1 to 5. Multiply the score of each by the weighting factor and insert the product in the shaded box. The products of each criteria are then totalled by summing the horizontal shaded boxes for each P2 option.

Form 14 provides a structured mechanism to properly compare different pollution prevention alternatives considering a wide range of criteria. Although important criteria, "equipment cost" or "payback" alone may not identify the best overall alternative.

Form 15

Options Analysis Form

Waste Stream Identification:
Root Causes:
Pollution Prevention Option:
Description:
Is pilot testing required?: Y / N Describe:
Equipment (include: • availability, • reliability, • example applications)
Special Considerations:
Potential Vendor(s): Competitve bids: **Y / N** Supplier support available: **Y / N**
Equipment Cost:
Maintenance Requirements:
Affect on product quality:
Effects on production:
Estimated waste reduction level:
Estimated cost savings:
Impact on employee health and safety:

Submitted by: _____ Date: _____

APPENDIX E: LIST OF SUBSTANCES OF CONCERN

APPENDIX E: LIST OF SUBSTANCES OF CONCERN

CANDIDATE TOXICS USED IN METAL FINISHING

Chemicals known to be used in the metal finishing industry are included in the following list. A "Toxicity Rating" has been provided for these chemicals based on their known or suspected environmental impact and based on their presence on one or all of: the NPRI list, the DOE ARET list, the MOEE Bans and Phase Outs list and/or the ODS.

Note: Although this rating is described as representing "toxicity" for simplicity, the rating refers to a broader indicator of environmental concern.

The following numeric ratings were applied to the compounds found on the various sub-lists or categories for each of the 4 major lists.

NPRI (National Pollutant Release Inventory) Index (see attached list)

1	Presence on list

ARET (Accelerated Reduction or Elimination of Toxics) Index

10	(List A-1)	Toxic, Bioaccumulative and Persistent
8	(List A-2)	Toxic, Bioaccumulative and Persistent; with qualifications
6	(List B-1)	Toxic and Bioaccumulative
4	(List B-2)	Toxic and Persistent
2	(List B-3)	Toxic

MOEE (Ministry of the Environment and Energy's Bans and Phase Outs Toxics) Index

10	(List 1)	Toxicity = 10[1] and Bioaccumulative and Persistent
8	(List 2A)	Toxicity = 10 and Bioaccumulative <u>or</u> Persistent
6	(List 2B)	Toxicity < 10 and Bioaccumulative and Persistent
4	(List 2C)	Toxicity < 10 and Bioaccumulative <u>or</u> Persistent

ODS (Ozone Depleting Substances) Index (see attached list)

10	100 % elimination by 1995
9	100 % elimination by 1996
5	100 % Elimination by 2020

A summary "Toxic Rating" was determined for each of the chemicals listed in the table based on the sum of the numeric ratings from the four indices.

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[1] Numerical rating based on data in the CESARS Database and the MOEE HCB's files

Chemical Name	Synonym	CAS #	NPRI Index	ARET Index	MOEE Index	ODS	Toxic Rating
acetone		[67-64-1]	1				1
alcohol			1	2			3
alkyl sulfonate							
aluminum dust		[7429-90-5]	1				1
aluminum, soluble compounds		[7429-90-5]			6		6
ammonia + compounds		[7664-41-7]	1				1
antimony + compounds		[7440-36-0]					
arsenic + compounds		[7440-38-2]	1	4	8		13
barium salts		[7440-39-3]					
benzene		[71-43-2]	1	2			3
bismuth + compounds		[7440-69-9]					
boron compounds		[7440-42-8]					
cadmium + compounds		[7440-43-9]	1	8	10		19
carbon disulfide		[75-15-0]	1				1
carbon tetrachloride		[56-23-5]	1	4	8	10	23
chlorinated paraffin waxes							
chlorine		[7782-50-5]	1				1
chloroform		[67-66-3]	1	4	8		13
chromium + compounds		[7440-47-3]	1	4	8		13
citric acid		[77-92-9]					
cobalt + compounds		[7440-48-4]	1	4	8		13
copper + compounds		[4770-50-8]	1	4	8		13
cresylic acid							
cyanides			1	4	8		13
dextrin		[9004-53-9]					
dichlorobenzene [1,4]		[106-46-7]	1		10		11
dichloromethane	methylene chloride	[75-09-2]	1	4	8		13
diethanolamine		[111-42-2]	1				1
dimethylamine		[109-89-7]					

Chemical Name	Synonym	CAS #	NPRI Index	ARET Index	MOEE Index	ODS	Toxic Rating
dioctyl phthalate	bis(2-ethylhexyl) phthalate	[117-81-7]	1	6	8		15
ethylene glycol		[107-21-1]	1				1
ethylenediamine		[107-15-3]					
fluorides							
formaldehyde solution		[50-00-0]	1				1
freon 113	trichlorotrifluorocarbon						
gallium + compounds		[7440-55-3]					
gelatin		[9000-70-8]					
glutamic acid		[56-86-0]					
glycine		[56-40-6]					
glycol ethers	ethylene glycol monomethyl ether	[110-80-5]					
gold+ compounds		[7440-57-5]					
hydrogen peroxide		[7722-84-1]					
hydroquinone		[123-31-9]	1				1
indium + compounds		[7440-74-6]					
iron + compounds		[7439-89-6]					
isopropanol		[67-63-0]	1				1
kerosene		[8008-20-6]					
lead + compounds		[7439-92-1]	1	4	8		13
magnesium salts		[7439-95-4]					
malic acid		[6915-15-7]					
manganese + compounds		[7439-96-5]	1		4		5
mercury + compounds		[7439-97-6]	1	4	10		15
methanol		[67-56-1]	1				1
methyl ethyl ketone		[78-93-3]	1				1
methyl isobutyl ketone		[108-10-1]	1	2			3
mineral acids			1				1
molybdenum + compounds		[7439-98-7]	1				1
naptha	petroleum benzin						

Chemical Name	Synonym	CAS #	NPRI Index	ARET Index	MOEE Index	ODS	Toxic Rating
napthalene		[91-20-3]	1				1
nickel + compounds		[7440-02-0]		4	8		12
2-nitropropane		[79-46-9]	1				1
oxalic acid		[114-62-7]					
palladium + compounds		[7440-05-3]					
perchloroethylene	tetrachloroethylene	[127-18-4]	1	4			5
phenol		[108-95-2]	1	2			3
phosphorus compounds		[7723-14-0]	1				1
pine oil							
platinum + compounds		[7440-06-4]					
polychlorinated biphenyls	PCBs			10	10		20
potassium salts		[7440-09-7]					
propylene		[115-07-1]	1				1
rhodium + compounds		[7440-16-6]					
ruthenium + compounds							
selenium + compounds		[7782-49-2]	1		6		7
silica							
silver + compounds		[7440-22-4]	1	4	8		13
sulphur compounds		[7704-34-9]					
thallium + compounds		[7440-28-0]					
thiourea		[62-56-6]	1	4	8		13
tin + compounds		[7440-31-5]					
titanium + compounds		[7440-32-6]	1				1
toluene		[108-88-3]	1				1
trichloroethane [1,1,1]		[71-55-6]				9	9
trichloroethane [1,1,2]		[79-00-5]	1				1
trichloroethylene [1,1,2]		[79-01-6]	1	2			3
trichlorotrifluoroethane		[76-13-1]					0
tungsten + compounds		[7440-33-7]					0
vanadium + compounds		[7440-62-2]	1				1
varsol							0

Chemical Name	Synonym	CAS #	NPRI Index	ARET Index	MOEE Index	ODS	Toxic Rating
xylenes		[1330-20-7]	1				1
zinc + compounds		[7440-66-6]		4	8		12
zirconium + compounds		[7440-67-7]					0

APPENDIX F: 8 STEP PROGRESS REVIEW

APPENDIX F: 8 STEP PROGRESS REVIEW

This Appendix contains questions that are based on the content of each of the Eight Steps in the Metal Finishing Pollution Prevention Guide. They can be used to help you keep track of your progress through the Steps.

ESTABLISHING A POLLUTION PREVENTION PROGRAM		
Step #1 Questions	Responses(✓)	
	YES	NO
Has the business established a pollution prevention program?		
Does it include management commitment to the program?		
Does the team include representatives from these areas:(Form 1-A)		
Management? Who?_____		
Environmental and process engineering including facility maintenance? Who?_____		
Operation and production? Who?_____		
Health and Safety? Who?_____		
Research and development? Who?_____		
Quality control and hazardous waste determinations? Who?_____		
Purchasing including material inventory and control? Who?_____		
Labelling, storage, and shipping of hazardous materials and wastes? Who?_____		
Maintaining regulatory or manifest records and selection and contracting with hazardous waste transporters? Who?_____		
Finance and accounting? Who?_____		
Personnel from other plants within the company? Who?_____		
Legal? Who?_____		
Outside consultants? Who?_____		

Step #1 Questions (Continued...)	Responses(✓)	
	YES	NO
Has a team leader or "champion" been chosen?		
Has the team developed a mission statement? (Form 1-B)		
Does the company have an Environmental Policy Statement?		
Is Pollution Prevention outlined in the Policy Statement?		
Has the team decided on the extent and priorities of the program for assessment and planning?		
Was the team briefed on general and implementable pollution prevention opportunities?		
Did the briefing include business specific information on waste minimization opportunities in any of the following areas:		
Inventory control of raw material supplies?		
Housekeeping, waste handling, labelling, and storage practices?		
Raw material substitution?		
Reclaiming, recycling, or reusing of waste streams?		
Energy conservation?		
Modification of processes, equipment, or operations with proven success for minimization of similar wastes?		
Waste concentration?		
Potential for redesign of processes and equipment to enhance recovery or recycling options?		
Redesign or reformulating end products to be less hazardous?		
Has a schedule with expected milestones been developed for implementing the program? (Form 2)		
Has the team identified the resources needed to reach the milestones?		
Has the team developed a plan to communicate on program progress?		
Will the plan address the needs of senior management?		

APPENDIX F

CONDUCT PRELIMINARY ASSESSMENT OF WASTE SOURCES		
Step #2 Questions	Responses(✓)	
	YES	NO
Has the self assessment Environmental Checklist been completed?(Form 3)		
Has the checklist been reviewed by the team prior to the site inspection?		
Did the team collect the following types of information:		
Design information including:		
Process flow diagrams?		
Existing material and heat balances (both design and actual) for production processes and pollution control processes?		
Operating manuals and process descriptions?		
Equipment lists?		
Equipment specifications and data sheets?		
Piping and instrument diagrams?		
Facility layout and elevation plans (including all sewer lines and drains)?		
Equipment layouts and work flow diagrams?		
Environmental information including:		
Hazardous waste manifests?		
Contracts with waste management firms?		
Emissions inventories?		
Biennial hazardous waste reports?		
Waste analyses?		
Environmental audit reports?		
Previous regulatory violations?		
Permits and Certificates of Approval?		
Raw material/production information for each unit process including:		

Step #2 Questions (Continued...)	Responses(✓)	
	YES	NO
Product composition and batch sheets?		
Material application diagrams?		
Material Safety Data Sheets (MSDSs)?		
Product and raw material inventory records?		
Operator data logs?		
Operating procedures?		
Production schedules?		
Economic information including:		
Waste treatment and disposal costs?		
Product, utility, and raw material costs?		
Operating and maintenance costs?		
Departmental cost accounting reports?		
Other pertinent information including:		
Business's hazardous waste minimization policy statement and description of existing waste minimization program?		
Business's environmental and health policy statements?		
Standard management procedures?		
Did the team consider the following waste streams:		
Wastewater effluents?		
Air emissions including stack and fugitive emissions (e.g. tank evaporation losses)?		
Hazardous wastes?		
Nonhazardous solid wastes?		
Did each member of the team become familiar with the layout, equipment and processes, waste generation, and types of waste generated?		
Has a block diagram of the facility areas and production processes been completed?		

Step #2 Questions (Continued...)	Responses(✓)	
	YES	NO
Has a rough input/output diagram been completed for the facility block diagram?		
Has a resources balance been done on the facility to identify magnitude of lost resources or wastes?		
Did the team prepare a site visit checklist including:		
Opportunities identified in the self-assessment Environmental Checklist? (Form 3)		
A list and full characterization of all waste streams and points of generation -- to be verified?		
A list of all waste minimization practices already in place that the pre-inspection review identified -- to be verified and evaluated?		
A list of proposed waste reduction options identified by the assessment team during the pre-assessment review -- to be verified?		
A list of other general waste minimization opportunities that might work for the specific type of business being assessed?		
Has a thorough site inspection of the facility been completed by the team?		
Did the team provide staff contacts in the areas being assessed with the site visit agenda several days before the inspection took place?		
While on-site, did the team:		
Schedule the inspection to coincide with the particular operation that is of interest (e.g., make-up chemical addition, bath sampling, bath dumping, start-up, shutdown, etc.)?		
Monitor the operation at different times during the shift, and if needed, during all three shifts, especially when waste generation is highly dependent on human involvement (e.g., in painting or parts cleaning operations)?		
Interview the operators, shift supervisors, and foremen in the assessed areas?		
Note their familiarity (or lack thereof) with the impacts their operation may have on other operations?		
Photograph the area of interest, if warranted?		

Step #2 Questions (Continued...)	Responses(✓)	
	YES	NO
Observe the housekeeping aspects of the operation?		
Check for signs of spills or leaks?		
Visit the maintenance shop and ask about any problems in keeping the equipment leak-free?		
Assess the overall cleanliness of the site?		
Pay attention to odours and fumes?		
Assess the organizational structure and level of coordination of environmental activities between various departments?		
Assess cost accounting procedures?		
Assess material purchasing procedures?		
Assess waste collection procedures?		
Have general observations been recorded? (Form 4)		
Have observations on inputs/outputs been recorded? (Form 5)		
Has the team met to review the observations from the site inspection?		
Have observations related to a waste sources been included in a comprehensive inventory of potential wastes? (Form 7)		
Have recommendations on the observations been noted?		
Has the unit operations data been consolidated into a process flow diagram for each production line?		
Has additional needed information been identified?		
Have sources for additional information been identified?		
Did the team review each waste stream to:		
Determine whether the wastes are hazardous or nonhazardous?		
Determine other physical and chemical characteristics of wastes and emissions?		
Determine actual points of generation?		
Determine quantities including variations?		
Identify all handling, treatment, or storage procedures on-site?		

Step #2 Questions (Continued...)	Responses(✓)	
	YES	NO
Has a complete listing of possible waste sources been produced from all team discussions on the site inspection and environmental checklist review?(Form 7)		
Does the complete listing include the Fate and Quantity of each waste source?		
Have housekeeping observations been identified for resolution by "Best Management Practices" and "Quick Fixes"?		
Has an action plan been formed to immediately implement the simple, low cost opportunities?		

PRIORITIZE WASTE SOURCES		
Step #3 Questions	Responses(✓)	
	YES	NO
Has the team completed a preliminary prioritization of the Wastes identified on Form 7?		
Has the team agreed on the ratings to be used for Fate, Quantity and Toxicity Rating? (Either ratings identified in Table 3-1 and Appendix E, or others assigned by the team)		
Has the team rated each Waste identified, using the three primary criteria? (Form 7)		
Has the team prepared a short list of Wastes for further prioritization?		
Has the team agreed on the ratings to be used for Impact Criteria and Changeability Criteria? (Either ratings identified in Table 3-3 and Table 3-4, or others assigned by the team)		
Has the team agreed on the weighting factors for each criteria? (Form 8)		
Has the team rated each Waste identified, using the Impact and Changeability criteria? (Form 8)		
Has the team chosen the number one priority waste stream for root cause identification?		

DETERMINE AND QUANTIFY ROOT CAUSES OF SELECTED WASTE SOURCES		
Step #4 Questions	Responses(✓)	
	YES	NO
Has a team been selected to identify root causes for the number one priority waste stream?		
Has the problem/concern of the priority waste stream been defined?		
Have all the possible causes been identified?		
Did the team use the **brainstorming** technique and the **"fishbone" diagram** to obtain a list of all possible causes of the problem? (Form 9)		
Did the team seek advice from company staff most familiar with the production process?		
Has a short list of the most likely (principle root) causes been selected?		
Was a criteria selected to quantify each root cause, (ie. mass of chromium lost per year)		
Were the six most likely primary root causes identified and ranked by the team using the **multi-voting** technique? (Form 10)		
Have areas or processes requiring further information been identified?		
Has necessary detailed information been collected on each of the top six primary causes?		
Has a separate flow diagram been prepared for each targeted process? (Form 11)		
Has unit operational data on material flows been identified? (make up rate; dumping frequency; drag-in, drag-out; evaporation) (Form 11)		
Has a material balance been completed over the targeted unit operations? (Form 12)		

GENERATE, ASSESS AND RECOMMEND POLLUTION PREVENTION ACTIONS		
Step #5 Questions	Responses(✓)	
	YES	NO
Has the team prepared a list of potential solutions for each major root cause?		
Has the team used the **brainstorming** technique to identify potential solutions?		
Have suppliers of equipment and chemicals been consulted?		
Have production operators and line employees been consulted for suggestions on improvements.		
Did the assessment team's waste minimization options include:		
Implementing segregation of solid wastes from aqueous waste streams and hazardous wastes from nonhazardous wastes?		
Implementing a maintenance program to prevent spills and leaks?		
Preventing overflows by installing adequate storage capacity or level controls?		
Installation of holding tanks for wash waters and rinse waters for reuse?		
Implementation of water conservation measures to reduce water consumption?		
Improved housekeeping and waste handling, segregation, and storage practices?		
Inventory control of raw material supplies?		
Raw material substitutions?		
Modification of processes, equipment, or operations to low waste technologies?		
Reclaiming, recycling, and reuse of waste streams and scrap materials?		
Listing the business's waste in waste exchanges?		
Detoxification or optimum treatment requirements?		

Step #5 Questions (Continued...)	Responses(✓)	
	YES	NO
Have the ideas been prioritized? (using multi-voting or Form 14)		
In setting priorities, did the team consider the following:		
Wastes which have high disposal costs?		
Wastes which fall under strict environmental regulation?		
Wastes which are generated from expensive raw materials?		
Wastes which adversely affect public health and the environment and increase risks?		
Wastes which cause processing, handling, storing, or discharge problems?		
The cost and return on investment for implementing a waste minimization practice for a certain waste?		
The effect on production and quality control?		
The ease of implementing and technical feasibility of the minimization options?		
The potential disadvantages of any waste minimization actions?		
Evaluate any new wastes minimization actions may generate and consider the possible difficulties you may encounter when attempting to dispose of these new wastes?		
Has a list of ideas needing more detailed information been generated?		
Has a list of ideas which can be implemented with minimum effort and cost been generated?		
Were the first screening and the ranking of waste minimization actions discussed with plant personnel and company management?		
Did the screening procedure consider the following questions:		
What is the main benefit gained by implementing this option? (e.g., economics, compliance, liability, workplace safety, etc.)?		
Does the necessary technology exist to develop the option?		
How much does it cost?		
Is it cost effective?		

Step #5 Questions (Continued...)	Responses(✓)	
	YES	NO
Can the option be implemented within a reasonable amount of time without disrupting production?		
Does the option have a good "track record"?		
If not, is there convincing evidence that the option will work as required?		
Does the option have a good chance of success?		
Has a list of other benefits of each option been prepared?		
Has a short list of options for further analysis been generated?		
Has each short-listed option undergone technical evaluation?		
Did the technical evaluation of an option consider facility constraints and product requirements, such as:		
Is the system safe for workers?		
Will product quality be maintained?		
Is space available?		
Is the new equipment, materials, or procedures compatible with current production operating procedures, work flow, and production rates?		
Is additional labour required?		
Are utilities available?		
Do they need to be installed, thereby raising capital costs?		
How long will production be stopped in order to install the system?		
Is special expertise required to operate or maintain the new system?		
Does the vendor provide acceptable service?		
Does the system create other environmental problems?		
Did production groups contribute to and review the evaluation?		
Did maintenance groups in the facility contribute to and review the technical evaluation?		

Step #5 Questions (Continued...)	Responses(✓)	
	YES	NO
Did purchasing groups in the facility contribute to and review the technical evaluation?		
Has each short-listed option undergone economic evaluation?		
Did the economic evaluation use:		
Payback period?		
Return on investment?		
Net present value?		
Business's own economic criteria?		
Has one or two options been identified for the primary root cause of the priority waste stream?		
Has a report on the a program to implement the options been prepared for management funding approval? (Form 16)		
Did the report include:		
Whether the technology is established, with mention of successful applications?		
The required resources and ways to get them?		
Estimated installation period?		
Estimated production down time?		
Process for evaluation of the project after implementation?		
Advantages of the proposal in relation to competing requests for capital funding?		
Has an action plan been prepared to carry out the options?		
Does the plan suggest engineering or feasibility studies of waste minimization options?		
Does the plan suggest implementing the more simple, low-cost waste minimization practices such as improved housekeeping, and waste segregation as soon as possible?		

IMPLEMENT AND MEASURE SOLUTIONS		
Step #6 Questions	Responses(✓)	
	YES	NO
Has a detailed implementation plan been prepared?		
Did the implementation plan consider:		
Past experience in the affected area of operation?		
How the implementation program fits into the business's overall strategy?		
Did the business have difficulty raising funds internally for capital investment to implement the waste minimization plan?		
Did the business consider: Private sector financing?		
Government-assisted funding?		
Has a measurement been chosen to track the effect of the change? (eg. quantity waste shipped per month, cost of raw materials per yearly sales)		

REPORT ON IMPLEMENTED SOLUTIONS		
Step #7 Questions	Responses(✓)	
	YES	NO
Does the team report on program progress to management?		
Are the reporting forms (Form 17) used?		
Does the team report on program progress to staff?		
Is a follow-up evaluation being used as a source of information for future uses of the option in other facilities?		

CONTINUOUS IMPROVEMENT		
Step #8 Questions	Responses(✓)	
	YES	NO
Has pollution prevention been integrated into the corporate plan?		
Has accountability for wastes been assigned to the operating units?		
Does the company information system track data to measure program results?		
Does management conduct an annual program review?		
Is staff educated in the waste minimization?		
Do employees publicize the company's pollution prevention progress at community meetings, schools etc?		
Is employee involvement promoted through a pollution prevention awareness program?		
Does employee training include the business's policy statement for pollution prevention planning (including why it is important and employee incentives for pollution prevention ideas)		
Were the waste assessment procedures evaluated by answering the following questions:		
Did the waste assessment meet its intended purpose?		
Did the assessment point out areas of inefficiency that enabled the company to improve production efficiency and waste management approaches and costs?		
Did the team receive cooperation from company personnel?		
Should there be a change in the composition of the team?		
Were there any information-gathering techniques that should be modified?		
Will the 8 Step process be repeated annually?		
Will another assessment be performed when there are changes in the following areas:		
A change in raw material or product requirements?		
Higher waste management costs?		
New regulations?		

Step #8 Questions (Continued...)	Responses(✓)	
	YES	NO
New technologies?		
A major event with undesirable environmental consequences (such as a major spill)?		

APPENDIX G: CASE STUDIES

APPENDIX G: CASE STUDIES

COMPANY "X"

Introduction

Company "X" was a dedicated metal finishing shop specializing in the machining, plating, and finishing of aircraft landing gear and flight control assemblies. The company volunteered as a test site to evaluate the draft Pollution Prevention Protocol which was developed by the project Task Force. Following the 8-step Protocol, a systematic approach to pollution prevention was exercised at the facility. The company had already incorporated a TQM-type philosophy into their everyday operations, which made implementation of the Program relatively easy.

Step #1 Establish a Pollution Prevention Planning Program

- **Forming a Pollution Prevention Team**

With the help of a facilitator, a Team was formed at Company "X", consisting of about ten (10) employees representing a cross-section of areas within the company. Management, production, health & safety, purchasing, waste water treatment, engineering, and TQM staff were included on the team as well as an outside facilitator and a consultant.

The Team developed a Mission Statement, followed by a list of general Team objectives and priorities. These policies were documented on the Team Form (Guide sample Form 1) and were found to be useful in keeping the Team focussed throughout the program.

- **Planning Schedule**

The complete program including projected milestones and Team meetings were scheduled using the Planning Schedule (Form 2). The schedule was updated regularly to reflect the ongoing status of the program. This was useful in maintaining Team momentum and clearly identifying goals within a reasonable time frame.

Step #2 Preliminary Assessment of Waste Sources

- **Environmental Checklist**

The first task for the Team was to complete the Environmental Checklist (Form 3). The purpose of the checklist was to evaluate current waste management and operating practices at the facility and identify potential areas for improvement by implementing "Best Management Practices" (BMPs). About forty (40) concerns were identified and are further discussed in Step #5.

- **Site Inspection**

With the leadership of an outside facilitator, the Team conducted a detailed site inspection, recording observations related to housekeeping and BMPs and identifying all potential waste sources on a multi-media basis. The roof area of the plant as well as other outside areas were included in the inspection. Thirty (30) observations were recorded on the Site Inspection Form (Form 4). These items were then grouped with the concerns identified from the Environmental Checklist. Action items to address these concerns were listed and are further discussed in Step #5. A comprehensive inventory of wastes also resulted from the site inspection. A list of more than 300 potential waste streams was generated using the Waste Inventory Form (Form 7).

- **In-house Data Collection**

Process drawings were collected which assisted the Team in understanding operations within the facility and the corresponding wastes generated from those operations. Other useful information collected by the Team included a purchase inventory, waste manifests, laboratory records, Material Safety Data Sheets (MSDSs), waste water treatment plant schematic, and invoice records. These sources of information were used to estimate quantities and costs associated with each waste stream. This information was essential for the next phase of the program, namely the prioritization of wastes.

Step #3 Prioritize Waste Sources

The Team decided that in order to short-list the more than 300 waste streams identified in the waste inventory, "Fate" and "Quantity" were the most suitable preliminary criteria to be applied to the waste streams. Scores from 1 to 5 were applied to each waste, with hazardous wastes (waste streams requiring treatment or disposed of off-site) and large quantities (ie. >500 gal/yr or lbs/yr) receiving the highest rating. The result was a list of twenty-nine (29) waste streams. The team then decided to further reduce the number of wastes to a more manageable number. This was accomplished using multi-voting which resulted in a list of 18 priority waste streams.

In order to prioritize the remaining waste streams, the Team selected secondary evaluation criteria under the headings of "impact" and "changeability" criteria. The Prioritization of Waste Sources Form (Form 8) was used for this exercise. Specific criteria were selected and biased relative to one another using a weighting system. The impact criteria selected included "health and safety", "cost of lost materials", and "cost to manage waste". Changeability criteria included "time to reduce/eliminate waste", "potential pollution reduction", "cost of change", and "impact on production". The Team then voted on the scores for each waste under the selected criteria. The result was a ranked list of the 18 priority waste concerns at Company "X". After considering the final scores, historical

knowledge of the processes and other intangibles, a multi-voting process resulted in three (3) waste streams to address initially. These included chrome plating bath spills, chrome plating rinse water, and Black Oxide process spills.

Step #4 Determine and Quantify Root Causes of Selected Waste Sources

In order to identify corrective actions for the 3 primary wastes, the root causes of each waste stream had to be identified. Using TQM techniques such as "brainstorming", "fishboning", and "multi-voting", a list of 4 to 6 primary causes was identified for each waste concern. After reviewing the available data, missing information was identified for these causes. A sampling/monitoring program was then developed to collect essential missing information. This included logging spills and procedures used, and collecting samples over a period of two months. The data collected were essential in providing baseline information related to the actual quantities and costs associated with the primary wastes.

Step #5 Generate, Assess and Recommend Pollution Prevention Actions

- **Examine Obvious BMP/Housekeeping Issues**

Approximately seventy (70) BMP/housekeeping concerns were identified from the Environmental Checklist (Form 3) and Site Inspection Form (Form 4). Recommendations to these concerns were documented as action items to be immediately considered for resolution.

- **Actions**

Together with an industry consultant and the program facilitator, brainstorming sessions were held to investigate potential solutions to the company's waste concerns. A facility Action Plan was developed which included the BMP/housekeeping resolutions as well as a plan for resolving the 3 primary wastes identified from the Step 5 process. The Plan outlined milestones to be completed over the next 2 to 4 years. Specific projects undertaken were as follows:

- *Reduction in chromium losses due to spills and ventilation system*

  Based on the information collected during the detailed assessment, the total annual chromium losses represented more than two-thirds of the annual chromium purchased. Solutions were planned to be implemented over a 4 year period at a capital cost of about $20,000. A target value of up to 50% reduction in losses was anticipated. Expected annual savings were conservatively estimated at about $2,000.

- *Elimination of spills from Black Oxide process*

Spills from this process not only represented a loss in raw materials, but more importantly represented a significant health and safety concern. Equipment changes were planned over a 12 month period. A target of 50% reduction in spills was expected. The capital cost of the equipment change was estimated at $10,000. A modest annual savings in raw material costs was expected however, the primary goal of this project was to eliminate or reduce the health and safety risk to employees.

Step #6 Implement and Measure Solutions

Step #7 Report on Implemented Solutions

Step #8 Continuous Improvement

Company "Y"

Introduction

Company "Y" was a dedicated metal finishing shop whose production focused on zinc and cadmium plating, as well as phosphating and chromating of automotive parts, electrical components, and hardware. The company volunteered as a test site to evaluate the draft Pollution Prevention Protocol which was developed by the project Task Force. Following the 8-step planning process, a systematic approach to pollution prevention was exercised at the facility. Company "Y" participated in both General Motors and Ford Quality Programs and were therefore well versed in Total Quality Management (TQM) principles.

Step #1 Establish a Pollution Prevention Planning Program

- **Forming a Pollution Prevention Team**

With the help of a facilitator, a Team was formed at Company "Y", consisting of six (6) employees representing a cross-section of areas within the company. Management, production, health & safety, and waste water treatment plant staff were included on the team as well as an outside facilitator and a consultant.

The Team developed a Mission Statement, followed by a list of general Team objectives and priorities. These policies were documented on the Team Form (Guide sample Form 1) and were found to be useful in keeping the Team focussed throughout the program.

- **Planning Schedule**

The complete program including projected milestones and Team meetings were scheduled using the Planning Schedule (Form 2). The schedule was updated regularly to reflect the ongoing status of the program. This was useful in maintaining Team momentum and clearly identifying goals within a reasonable time frame.

Step #2 Preliminary Assessment of Waste Sources

- **Environmental Checklist**

The first task for the Team was to complete the Environmental Checklist (Form 3). The purpose of the checklist was to evaluate current waste management and operating practices at the facility and identify potential areas for improvement by implementing "Best Management Practices" (BMPs). Nine (9) concerns were identified and are further discussed in Step #5.

- **Site Inspection**

With the leadership of an outside facilitator, the Team conducted a

detailed site inspection, recording observations related to housekeeping and BMPs and identifying all potential waste sources on a multi-media basis. The roof area of the plant as well as other outside areas were included in the inspection. Forty-five (45) observations were recorded on the Site Inspection Form (Form 4). These items were then grouped with the concerns identified from the Environmental Checklist. Action items to address these concerns were listed and are further discussed in Step #5. A comprehensive inventory of wastes also resulted from the site inspection. A list of more than 300 potential waste streams was generated using the Waste Inventory Form (Form 7).

- **In-house Data Collection**

Process schematics of the plating lines were collected which assisted the Team in understanding operations within the facility and the corresponding wastes generated from those operations. Other useful information collected by the Team included a purchase inventory, plant layout diagram, laboratory records, Material Safety Data Sheets (MSDSs), waste water treatment plant flow sheet, water expense records, and a WHMIS training manual. These sources of information were used to estimate quantities and costs as well as the hazardous nature associated with each waste stream. This information was essential for the next phase of the program, namely the prioritization of wastes.

Step #3 Prioritize Waste Sources

The Team decided that in order to short-list the more than 300 wastes identified in the waste inventory, "Quantity" would be the most suitable preliminary criteria to be applied to the waste streams. After screening those wastes of insignificant quantity, an initial short-list of significant wastes resulted in about 70 waste concerns. After the Team reviewed the remaining waste streams, certain concerns became very apparent. The wastes were grouped by the Team into eight (8) primary categories which included spent alkaline cleaners, cadmium cyanide solutions, zinc cyanide solutions, spent acids, dichromate wastes, phosphate wastes, zinc chloride solutions, and waste oils. Process rinse waters were also considered to be a significant waste concern.

The 8 primary waste concerns were then transferred to the Prioritization of Potential Waste Sources Form (Form 8). Ranking criteria were established by the Team and inserted on the form. After selecting a relative weighting for each criteria, scores were established for each of the 8 waste concerns. Three (3) primary waste concerns were identified as a result of the prioritization exercise:

- *Process Rinse waters*
- *Waste Acids*

- *Spent Cleaners*

Step #4 Determine and Quantify Root Causes of Selected Waste Sources

Information collected related to the three primary waste concerns was reviewed and important missing information was identified. Detailed information was then collected as needed.

- *Process Rinse waters*

  A typical monthly water invoice for Company "Y" showed consumption at more than 25,000 m^3 at a cost of more than $19,000. The flow rate of treated rinse water reporting to the sanitary sewer was estimated at about 600 L/min. Based on the available data, it was apparent that a great potential for water recycling existed. Metal contamination was low, however a high level of Cl^- was present due to the dumping of large quantities of spent HCl through the waste water treatment system.

- *Waste Acids*

  A sample of spent acid solution was analyzed at an outside laboratory. A significant concentration of metals was present in the waste acid, including high levels of iron (Fe) and zinc (Zn). Acid consumption was at about 154 m^3/yr at a cost of $100,000 annually.

- *Spent Cleaners*

  From the data collected, an estimated 300,000 L/yr of spent alkaline cleaning solution was dumped to the waste water treatment system. The baths are dumped on a monthly basis. The replacement costs of the cleaners were estimated at about $200,000/yr. A detailed characterization of both virgin and spent cleaning solutions was conducted by the facilitator to assist in the evaluation of appropriate recovery systems.

Step #5 Generate, Assess and Recommend Pollution Prevention Actions

- **Examine Obvious BMP/Housekeeping Issues**

Approximately fifty-four (54) BMP/housekeeping concerns were identified from the Environmental Checklist (Form 3) and Site Inspection Form (Form 4). Recommendations to these concerns were documented as action items to be immediately considered for resolution.

- **Actions**

Together with an industry consultant and the program facilitator, brainstorming sessions were held to investigate potential solutions

to the company's primary waste concerns. A facility Action Plan was developed which included the BMP/housekeeping resolutions as well as a plan for resolving the 3 primary wastes identified from the Protocol. The Plan outlined milestones to be completed over the next two to three years. Actions currently being undertaken for the three projects are as follows:

- *Process Rinse waters*

  Due to the high flow rate of water being treated on site (600 L/min), a significant savings in water costs would be realized if the water could be recycled. Since the level of Cl^- is very high in the final treated waste water, the water is currently unsuitable for use. In order to make water recycling practical, waste acid dumps and acid pickling rinse waters must be reduced or diverted from the final treatment plant. Solutions to this problem are currently being investigated, with the outcome somewhat dependent upon the *Waste Acid* project. The company plans to complete the water recycling project over a two year period at an estimated capital cost of $400,000. Reduction in water consumption is targeted at 80%. Annual savings are anticipated to be about $80,000/yr.

- *Waste Acids*

  Spent acid is currently hauled off site (for recovery) at a cost of $0.20/L. Based on an estimated monthly haulage of 5600 L, the disposal cost of this waste acid is about $13,500/yr. Unused acid is about 10 to 15% (v/v) in a spent acid bath which is approximately 1/3 of the original acid concentration. This represents a lost acid value of about $14,500/yr giving a total annual cost of the waste acid of about $28,000/yr. Different acid recovery systems are being investigated currently. The company plans to reduce lost acids by 80%. The project is expected to take two years to complete, with an expected capital investment of about $35,000. Annual savings are expected to be about $22,000.

- *Spent Cleaners*

  The company is currently considering implementing line specific treatment units to remove oils and smut, with the recovered cleaning solution returned to the process. If the company follows this approach, five filtration units will be purchased at a total capital cost of about $200,000. The project is expected to be completed within two years, with a reduction in dumped cleaning solution targeted at 80%. Annual savings are expected to be about $100,000/yr.

Step #6 Implement and Measure Solutions

Step #7 Report on Implemented Solutions

Step #8 Continuous Improvement

APPENDIX H: BETTER STANDARD PROCEDURES FOR POLLUTION PREVENTION PLANNING

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Cleaning

All metal finishing processes require that parts to be finished be free of organic and inorganic soils, including oils, scale, buffing and polishing compounds.

There are three basic types of cleaners in use:

Solvents
Vapour degreasers
Alkaline detergents

Solvent and vapour degreasing cleaning methods have been almost totally replaced by alkaline materials where the following processes are wet. Solvents and vapour degreasers are still in use where the part must be clean and dry with no further wet processing. Even here, there is an increase in alkaline cleaning followed by a drying process.

Solvents such as terpenes are, in some instances, replacing volatile solvents. Less toxic materials such as 1,1,1, trichloroethane have been substituted for more hazardous materials in vapour degreasing.

Alkaline cleaning cycles usually include a soak (or spray) immersion followed by an anodic electroclean, and that is typically followed by a weak acid immersion. There will be appropriate rinsing between the electroclean and acid cycles as well as following the acid.

Formulation of such cleaners are most often proprietary but are likely to contain sodium hydroxide and a silicate. The electroclean will contain chemicals to enhance conductivity.

Non-etching/non-silicated cleaners are typically used to clean aluminum.

The acids may be sulphuric, hydrochloric, phosphoric or nitric. The choice of cleaners and acids will be dependent on the substrate and the nature of the soil.

Anodizing

The electrochemical process to thicken the oxide film on the metal surface.

It is most frequently applied to aluminum.

Parts to be treated are made anodic in dilute chromic or sulphuric acid solutions. The oxidation process takes place at the metal/metal oxide interface. Therefore, the oxide grows from within rather than

building up from the surface.

Conversion Coating

These processes include chromating, passivating and phosphating and may include colouring.

Chromating - performed by immersion in hexavelant chromium solution with active organic and inorganic agents.

The protective coating formed becomes a gel, which hardens on drying.

Phosphating - This operation is performed by immersion of steel or zinc in dilute phosphoric acid with other agents to produce desired finished properties.

Both chromating and phosphating are used as bases for painting.

Passivation - This effect is produced by immersing the metal part in an oxidizing acid solution. It may be nitric acid or nitric acid with Sodium dichromate.

Colouring - this involves providing an oxide or complex of oxides and other elements to a surface to produce an aesthetic effect.

Electroless Plating

In this type of plating, a deposition of metal is accomplished on a substrate without the application of electricity.

The most common use is copper or nickel electroless deposition in the main manufacture of printed circuit boards. Its purpose is to effect deposition of a conductive plate through holes drilled in the boards. It is also used to deposit a plateable surface on plastic parts to be followed by conventional electroplate and is accomplished using an accelerator and catalyst.

Electroplating

Electroplating involves the deposition of a thin coat of metal onto another metal.

The substrate may be either ferrous or non-ferrous.

Process baths in use include Zinc, nickel, copper, chromium, cadmium, tin. brass, bronze, lead, tin-lead, gold silver and some other exotic metals such as platinum.

Baths include metals in solution in acid, alkaline, neutral and alkaline cyanide formulations.

Chemical Milling and Etching

These are controlled dissolution immersion processes using chemical reagents and etchants.

Electrochemical brightening is similar with the part made anodic.

Aluminum is typically etched in caustic prior to anodizing or chemically brigthened in a solution which could contain nitric /phosphoric /sulfuric acids.

Hot Dip Coating

The application of metal to a workpiece by immersion in molten metal. By far the major application is zinc on steel (galvanizing). There are some applications of tin on steel.

Printed Circuit Boards

The manufacture of printed circuit boards is a complex process involving the application of electroless plating, electroplating and etchants. In addition, there are inks, resists, sensitizers, resist solvents and strippers.

Processes may be additive or subtractive.

Waste Reduction through Good Management Practices

All metal finishing companies are aware of many of the opportunities for waste reduction but there are some reminders that can be emphasized.

- All plant employees need instruction on good waste management practices.
- Process and waste treatment operators need the best training available with continuous upgrading as new ideas evolve.
- Can you add more counter current rinsing and/or conductivity controls?
- Can you get a little more drainage time?
- Will the use of more or better wetting agents help?
- Keeping process temperatures as high as possible may cost a little more in energy but will lower viscosity and increase the possibilities in drag-out recovery.
- Spray rinsing over the process tank or in the reclaim can be very effective but will probably require DI water, and the nozzles must be kept clean.
- Air agitation in rinses will substantially increase rinsing

efficiency but the air must be oil free.

- Misting over plating tanks can be reduced with plastic balls if the part configuration does not tend to drag them out.

- Improving of filtration on plating tanks may reduce frequency of purification treatment as well as improving plating.

- If a process calls for brightening of copper or brass parts such as elbows for plumbing, consider substituting nitric acid with a sulphuric hydrogen-peroxide solution. Electrolytic recovery is then a possibility.

- Avoid floor level valves on process and recovery tanks.

- There is as much metal lost through leaking valves, accidental overflows, spills, filter cleanouts, purification treatment sludges, stripper dumps, chromating bath dumps as is lost through the running rinses. At the very least, there should be curbing around all process areas that have potential- hazardous materials. Some companies now curb all doorways leading from process areas.

- Consider a separate treatment for potentially recoverable metals such as nickel.

- Substitute a non or less hazardous material for what is now in use. Cyanides may make cleaning easier but the effort to replace them where possible can have a substantial pay-off.

- Re-use of treated water in cleaning cycles can reduce water consumption but must be controlled to prevent build-up of sulphates and chlorides.

- Check out the recovery systems available. There might be some good used equipment on the market. The best opportunities are with ion exchange (not necessarily fully automated) atmospheric evaporation, vacuum evaporation, electrolytic recovery, and of perhaps less potential, reverse osmosis and electrodialysis.

- Make sure that there are drainage boards between tanks and see that they are kept in position and actually draining in the proper direction.

- There are very few installations to-day that do not have drag-out recovery systems. The recurring complaint that they tend to increase the impurity build-up in the process tank has been met to a large extent by the reduction of drag-in of contaminants and the improvement in cleaning systems. If there is room for a drag-out and three rinses, it might be worthwhile to consider two drag-outs and two counter-flowing rinses.

- Standard procedures should include the frequency with which tanks are dragged for fallen parts.

- Similarly, the frequency of inspection of tanks and equipment should be defined.

- There is no substitute for management's critically objective walk-through.

Carrying a check list can be helpful and the record that is made may be useful in tracking problems.

Waste Reduction Options in Materials Handling, Storage and Transfer

- Written procedures for shipping, receiving and handling of materials, combined with training of shippers, receivers and lift truck operators, can substantially reduce waste and accidental spills.

- Careful inspection of incoming goods for container damage and confirmation of contents will prevent unusable materials from being added to inventory.

- Date marking of containers will permit first in, first out material utilization.

- When interest rates were high, it became essential for inventories to be kept at a minimum. This practice remains viable since the smaller the inventory, the smaller the risk.

- Safe, dry storage is not only important for the health of employees but it also provides for less accidental spillage.

- Packaging is usually dictated by the customer and the supplier. While it is difficult to change the customer's approach to packaging, it may be possible to persuade the supplier to minimize bulk while providing safe containers.

- Dispose of obsolete material as fast as possible, even if it has no financial return. The "pack rat" philosophy is of no advantage here.

- The "Blue Box" thinking has become well established in the minds of most people. Take advantage of it by having lots of clearly marked containers throughout the plant. Inspect these containers on every plant walk through. There will always be something to correct and the impression that management is serious will have some benefit.

Better Standard Procedures for Pollution Prevention Planning

When management decides to commit to an organized pollution

prevention programme, the first principle of responsibility lies within itself. Consequently, it needs to write a set of standards for itself, which can lead into the specific directions that are contained in the procedures for the operation of the facility. These directions will include schematics for each step of the management hierarchy and the responsibilities appropriate to that level, reporting of the follow up at each level, procedures to be followed when anomalies occur and the consequences thereof.

The supervisor can then oversee daily operations with the knowledge of the companies' policies and with the written standard procedures for each process; with these directives, he has the tools to carry out his responsibilities.

Better Standard Procedures

The use of written process procedures in the metal finishing industry varies from next to none to detailed operations manuals in some companies.

It is not high on the list of priorities for the many companies that have limited personnel, with the responsibility then falling on the owner/manager. But, consider the possible advantages.

- "Due Diligence" is a legal defence that is used when a company or an individual is charged with an offence resulting from the operation of a facility; this defence would entail the claim that every reasonable care was taken to avoid the resultant actions for which they have been charged.

To use this defence successfully, it is necessary to have written procedures and detailed records to establish that these procedures are being adhered to.

- Written instructions for operators of the processes and, in particular, the operator of the waste treatment system can greatly improve the chances that the correct steps will be taken.

- These procedures should include the frequency with which supervisors review the operations and their reports on what is found. Similarly, management should have a review programme and written record reports of findings.

- In many instances, the operators may not have English as their first language, however, there is usually someone to whom they can refer on their shift able to answer their problem. It has been the experience of the industry that second and third shifts have been the places where most errors occur. Many of these problems could be avoided by easy access to up-to-date standard procedures.

APPENDIX H

References

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Electroplating Engineers Handbook Fourth Edition - Lawrence J. Durney

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APPENDIX I: POLLUTION PREVENTION PLANNING FOR SPECIFIC WASTE SOURCES

APPENDIX I: POLLUTION PREVENTION PLANNING FOR SPECIFIC WASTE SOURCES

The focus of this Appendix is on specific waste streams and potential opportunities for pollution prevention that are applicable to these waste streams.

Spent Plating Solutions

General Bath Life Extension

Extending the useful life of a process bath is an effective means of source reduction of waste. Spent baths must be treated either off-site or on-site by the waste treatment system. Several methods of extending bath life are described below.

Filtration: The accumulation of solids reduces the efficiency of the process bath, and removal of these contaminants can extend the life of the bath. Various types of equipment are used to remove suspended solids from plating solutions, with the most common being cartridge filters and precoat (diatomaceous earth) filters. Cartridge filters are available in either in-tank or external configurations. Most cartridges are disposable, but washable and reusable filters are now available.

Carbon Treatment: Carbon treatment of plating baths can be used to remove organic contaminants, either on a continuous or batch basis. The carbon adsorbs organic impurities and is periodically changed and disposed of. The most common applications reported in one study were nickel electroplating (mostly Watts nickel and nickel sulphamate), followed by copper electroplating (mostly copper cyanide and copper sulphate), zinc plating and cadmium cyanide plating, respectively.

Replenishment: The effectiveness of a bath decreases with use, but control may be achieved by disposing of only a portion of the bath and replenishing the remainder with fresh chemicals and water. This practice can help to extend bath life, and there are various automated bath monitoring and replenishing systems currently available for this purpose. Alternatively, baths can be adjusted manually by the operator after monitoring key bath characteristics, such as pH or metal concentration.

Purified Water: Natural contaminants found in tap water, such as calcium, iron, magnesium, manganese, chlorine, carbonates, and phosphates have a deleterious effect on plating operations. These substances reduce rinse water efficiency and decrease the potential for drag-out recovery. In process baths, these contaminants decrease bath life and thereby increase the frequency of process bath dumping. In addition, these contaminants increase the volume of sludge produced in a conventional waste water treatment system. It is therefore advantageous to utilize purified water for process bath make-up and rinsing. Purification may be accomplished by deionization, distillation or reverse osmosis.

In addition, purified water may permit water re-use options that are not possible with tap water. This in turn may reduce the size of the water purification system required as compared to current water use.

Electrolytic Dummying: Some metal contaminants that enter the plating bath with the workpiece can sometimes be selectively plated-out by a process called "dummying". A trickle current is run through the system, and the selected removal of the contaminant metal extends the bath life. The contaminant metals that are most commonly plated-out are copper, zinc, iron and lead. Treatment can be batch or continuous, with batch treatment usually performed in the process tank during down-time.

Cyanide Bath Carbonate Freezing: Carbonates are formed in cyanide baths by the breakdown of cyanide, excessive anode current densities and the adsorption of carbon dioxide from the air. Excessive carbonates increase the resistance in the bath, resulting in low plating current densities and adversely affecting the smoothness of deposits, plating efficiency and plating range. Carbonates can be removed from sodium cyanide baths by lowering the bath temperature to approximately -3°C, where the low solubility of the carbonate salt results in crystallization, permitting subsequent removal from the bath.

Precipitation: Some metal contaminants that enter the plating bath as impurities in anodes can be removed from certain plating baths by chemical precipitation. The precipitate can then be removed by bath filtration. Precipitation is an alternative method to carbonate freezing for cyanide baths and is especially applicable to potassium cyanide baths. Chemicals used for this purpose include barium cyanide, barium hydroxide, calcium hydroxide, calcium sulphate or calcium cyanide.

Monitoring: Continuous or frequent monitoring of bath parameters can permit the determination of the need for chemical addition or contaminant removal. More frequent bath maintenance can prolong bath life.

Housekeeping: The prevention of bath contamination by foreign material can significantly prolong bath life. Prompt removal of dropped parts, good rack cleaning, and incoming air filtration are examples of good housekeeping practices.

Drag-in Reduction: The liquid from the preceding bath that adheres to the workpiece and gets dragged-in to the subsequent tank reduces bath life and effectiveness. Rinsing helps prevent cross-contamination of process baths by removing drag-out into the rinse bath, so that the drag-in to the next process bath is only rinse water.

Purer Anodes and Bags: Impurities in anodes will contaminate a process bath. The anodes can be immersed in cloth bags to prevent

insoluble impurities from entering the bath, but the bags must be compatible with the process solution and must be regularly maintained. Alternatively, more expensive but more pure anodes may be used, which would decrease this source of bath contamination.

Ventilation/Exhaust Systems: Ventilation and exhaust systems can generate waste and increase bath losses. If segregated, some wastes from scrubbers can be filtered and returned to the process bath. Process baths that generate mist should be in tanks with more freeboard in order to reduce the amount of mist that reaches the ventilation system. Foam blankets and polypropylene balls can also be used for this purpose.

Specific Processes

Hexavalent Chrome Alternatives: Trivalent chromium plating solutions can be used for decorative plating to replace hexavalent chromium. The use of trivalent chromium eliminates the reduction step in the waste water treatment process, and eliminates the problems associated with hexavalent chromium bath misting. In addition, trivalent chromium baths operate with a lower viscosity and lower concentration than do hexavalent baths, thus decreasing bath drag-out. Chrome conversion coatings for paint pretreatments can sometimes be replaced by non-chrome conversion coatings or no-rinse chrome chemistries.

Nonchelated Process Chemistries: Chelators are used in process baths in order to control the concentration of free metal ions in the solution. Unfortunately, chelating compounds inhibit the precipitation of metals so that additional chemicals must be used in waste water treatment, which consequently increases sludge volume. Also, some spent process baths contain chelators which may not be effectively treatable on-site, resulting in increased hazardous waste disposal costs. Nonchelated process chemistries can be used for some cleaning processes in which it may not be necessary to keep metals that have been removed from the workpiece surface in solution. These metals can be allowed to precipitate but must be subsequently removed by filtration. Continuous filtration of the nonchelated process bath results in increased operating costs, but savings will be realized in reduced waste treatment and handling costs.

Noncyanide Process Chemicals: Waste streams containing free cyanide are typically treated using sodium hypochlorite or chlorine to accomplish oxidization, and complex cyanides are commonly precipitated using ferrous sulphate. These chemicals contribute to sludge volume, so that using noncyanide process chemistries may both eliminate a treatment step and reduce sludge volume . However, many noncyanide processes are difficult to treat and produce more sludge than cyanide baths. Therefore, users will have to determine the specific advantages and disadvantages of switching processes in their facility.

Solvent Degreasing: Solvent degreasing of workpieces before

processing may be replaced by hot alkaline cleaning baths. Solvent use requires off-site recycling or disposal, or on-site recycling with only solvent sludge disposal off-site, whereas alkaline baths can be treated on-site. The effectiveness of alkaline cleaners can be enhanced by applying an electrocurrent or ultrasonics, and the benefits of avoiding solvent vapours and sludges often outweigh any additional operating costs.

Alkaline Cleaners: Alkaline cleaners are typically discarded after the accumulation of oil, grease and soils from use reach a level which impairs the cleaning efficiency of the bath. Several means are available for removing these contaminants and thereby extending the life of the bath. Free floating oils can be removing by simple skimming devices. Particulate can be removed by settling and/or cartridge filtration. Some emulsified oil (as well as free oil) can be removed by an oil-water coalescer. However, the most effective means of alkaline cleaning bath filtration is to use microfiltration or ultrafiltration. With these membrane technologies, the emulsified oils from the cleaning bath are separated from the aqueous cleaning solution, resulting in a small residual of oily-water waste (typically 10% of the original bath volume) and a recycled cleaner requiring only fortification. Cost savings result from a decrease in new cleaner purchases and a reduction in spent cleaner requiring treatment or off-site disposal.

Caustic Etch Solution Regeneration: Dissolved aluminum can be removed from a caustic etch bath by precipitating the aluminum as a hydrate which can be reused in a number of applications.

Acid Purification: The bath life of sulfuric acid anodizing solutions ca be extended indefinitely by removing the dissolved aluminum using a specialized ion exchange process.

Drag-out Reduction

Reducing the volume of drag-out from process baths serves to reduce the amount of valuable process chemicals that contaminate the rinse water, which in turn reduces the amount of sludge that is generated by a conventional metal precipitation treatment system. Several methods of reducing drag-out are discussed in general terms below.

Process Bath Operating Concentration: Drag-out can be reduced by keeping the chemical concentration of the process bath at the lowest acceptable operating level, since in general, the greater the concentration of chemicals in solution, the greater the viscosity. Consequently, the film that adheres to the workpiece as it is removed from the process bath is thicker and requires more time to drain back into the process tank. In addition, the chemical concentration of the drag-out film is greater.

Process Bath Operating Temperature: The viscosity of the process solution can be reduced by increasing the bath temperature, which in-

turn reduces drag-out since the film drains from the workpiece more quickly. However, a limit on the operating temperature is usually imposed by the brighteners which break down, and in cyanide solutions by the increased build-up of carbonates. Operating process baths at higher temperatures increases the evaporation rate from the tank, and water from the following rinse tank can be used to replenish the process bath.

Wetting Agents: Wetting agents can be added to a process bath in order to reduce the surface tension of the solution and thereby reduce the drag-out loss. However, wetting agents can create foaming problems in process baths, and bath chemistries should be evaluated for their compatibility with wetting agents. Also, the effect of these agents on the waste water treatment or rinse water recovery system needs to be assessed.

Workpiece Positioning: Drag-out loss can be reduced by strategic positioning of the workpiece on the rack. Workpieces should be oriented so that the adhering film drains freely and does not get trapped in grooves or cavities. Parts should be tilted so that drainage is consolidated, since fluid flowing together in a preferred route will drain more quickly. Parts should not be positioned directly over one another, in order to avoid drainage onto the part below. Finally, the workpiece should be oriented so that only a small surface area contacts the solution surface as the workpiece is removed from the process bath.

Withdrawal and Drainage Time: The faster a workpiece is removed from the process bath, the thicker the film on the workpiece surface and thus the greater the drag-out volume. The effect is so significant that it is believed that most of the time allowed for drainage of a rack should instead be used for withdrawal only [13].

Air Knives: As the workpiece rack is raised above the process tank, air can be blown at the workpieces to improve the drainage of the drag-out solution into the process bath. High humidity air can be used in order to counteract workpiece drying.

Spray or Fog Rinses: Spray or fog rinse systems can be used above heated baths to recover drag-out on the workpiece. Purified water should be used for these systems in order to reduce bath contamination from the rinse water. The spray rinse flow rate should be adjusted to be equal to the evaporation rate of the tank, so that the spray rinse is used to replenish the process bath.

Plating Baths: Contaminated plating baths can increase drag-out by as much as 50% because of the increase in solution viscosity (for example, a cyanide plating bath contaminated with carbonate). Consider freezing out carbonates. Organic contaminants can be removed with activated carbon filters. Quick removal of fallen workpieces helps to prevent contaminant accumulation. Avoid drag-in of contaminants. See also Bath Life Extension.

Drainage Boards: Drain boards capture process solution that drips from the workpiece rack as it is moved from the process bath to the rinse system, and return the solution to the process bath. Drain boards should cover the space between the process tank and the rinse tank which also serves to prevent drippage onto the floor. Removable drain boards have the advantage of still permitting access to the space between the tanks.

Drag-out Tanks: Drag-out tanks, also called dead or static rinse tanks, are essentially rinse tanks that operate without a continuous flow of water and the workpiece is placed in the drag-out tank before the standard rinsing operation. Thus, drag-out from the process bath is captured in the drag-out tank, where the chemical concentration increases over time. Eventually, the chemical concentration in the drag-out tank will increase to the point where it can be used to replenish the process tank. For this reason, drag-out tanks are primarily used in conjunction with process baths that operate at an elevated temperature where evaporation is significant. Purified water should be used in the drag-out tank so that contaminants do not build up in the process bath where the drag-out solution is used for replenishment.

Drag-out Recovery

Recovering the drag-out from process baths offers the potential for significant savings due to the reduction of bath replenishment costs and the reduction of waste water treatment requirements. Several methods of recovering drag-out are discussed in general terms below.

Evaporation: Evaporators can be used for recovery of chemicals in rinse water. The evaporator usually operates off the plating bath, in order to enhance the rate of evaporation of water from the bath to make room for the addition of the rinse overflow from the first rinse tank. The most common uses are for chromium and nickel plating baths. Atmospheric evaporators are the most common, which operate at atmospheric pressure and elevated temperatures. Vacuum evaporators are a more expensive alternative, but they are more energy efficient and they recover the water vapour for use as make-up water. In addition, vacuum evaporators can be used for solutions that are heat sensitive, or for alkaline cyanide solutions where the build-up of carbonates is problematic due to the aeration used in atmospheric evaporators.

Ion Exchange: Ion exchange is a chemical reaction wherein an ion from solution is exchanged for a similarly charged ion attached to a resin bed. Ion exchange can be used for chemical recovery of rinse water, or in select cases for plating bath maintenance. With rinse water recovery, both an anion and a cation exchange resins are used in order to "deionize" the water, and the rinse water can be recirculated in a closed loop. When the capacity of the unit is reached, the resin is "regenerated" and the ions are concentrated into a manageable volume of solution. Ion exchange has been used for

rinse water recovery with nickel plating, chromium plating, non-cyanide zinc plating, cadmium cyanide plating and gold cyanide plating.

The major use of ion exchange in plating bath maintenance is for the removal of iron and trivalent chromium from hexavalent chromium plating solutions. These cations reduce the performance of the bath, but can be removed by ion exchange while the chromate anions remain in solution.

Ion Exchange: Ion exchange can be used to remove some metals dragged of electrolytic baths for anodized aluminum.

Electrowinning: Electrowinning is an electrolytic process whereby the dissolved metals in the solution are reduced and deposited on the cathode. The deposited metal is subsequently recovered either by scraping or chemical means, for reuse as anode material or for off-site refining/reuse. Electrowinning can thus be used to recover metal from a drag-out tank, allowing return of the "electrowinned" solution to the rinse tank. However, because electrowinning does not remove all dissolved solids, the drag-out solution must periodically be purged in order to control the accumulation of dissolved solids. Electrowinning is used in a wide variety of plating applications, including gold, silver, copper, cadmium, and zinc plating operations.

Electrodialysis: Electrodialysis utilizes ion-permeable membranes and applied current in order to separate ionic species from an aqueous solution. It is primarily used for recovery of nickel from rinse tanks, where it allows the return of concentrated nickel solution to the plating bath. The potential advantage of electrodialysis is that the selectivity of the membrane can be chosen so as to permit the recovery of desirable plating bath organic constituents (such as saccharin), while inhibiting the recovery of some undesirable organic materials that would otherwise accumulate. Thus, electrodialysis can be more effective than other recovery methods such as evaporation and reverse osmosis.

Reverse Osmosis: Reverse osmosis is a separation process that utilizes a semi-permeable membrane to produce purified water and a concentrated ionic solution from a feedstock of dilute solution. High pressure is used to force the water through the membrane, while most dissolved salts are retained by the membrane. The concentrated components can be recovered and then returned to the process bath, and the treated water can be reused as a high quality source of rinse water. The most common application of reverse osmosis in the metal finishing industry is in the recovery of drag-out from nickel plating solutions. The advantages of this technology over competing processes (such as evaporation) are that it is a low temperature, low energy process, which generates a recovered water stream of acceptable quality for reuse as rinse water. The drawbacks are that the membranes can be fouled by suspended solids and/or precipitation products, necessitating cleaning and/or replacement, and that the

membranes have a limited lifetime. Furthermore, reverse osmosis concentrates (and thus returns to the process) both essential plating chemicals and unwanted impurities, unless some post-treatment is performed, but this aspect is common to other recovery options as well.

Meshpad Mist Eliminators: Meshpad mist eliminators are used to recover plating chemicals that are entrained in the exhaust gas from the plating tank. They are most commonly used with chromic acid baths, but are also used with caustic, cyanide, hydrochloric acid, nitric acid, and sulphuric acid baths. Mist eliminators are an alternative to scrubbers, and they are typically used in a dedicated manner, with one mist eliminator installed within the exhaust system duct work of each plating tank. This configuration makes return of the captured chemicals to the plating tank more feasible than with a scrubber which may service multiple exhaust streams.

Rinse Water

Most of the hazardous waste produced in a metal finishing facility comes from waste water generated by the rinsing operations that follow cleaning and plating operations. By increasing rinse efficiency, a facility can significantly reduce waste water flow with savings resulting from the cost of water and waste water treatment. Treatment chemical use and sludge generation should be reduced, with the amount dependent on rinse water hardness and the sludge precipitation chemicals used. Also, clarification/filtration efficiency should be increased, as should the overall treatment plant spare capacity.

Improved Rinsing Efficiency

There are three basic strategies which can be used to enhance the rinsing process. First, turbulence can be generated between the workpiece and the rinse water. Second, the contact time between the workpiece and the rinse water can be increased. Finally, the volume of rinse water in contact with the workpiece can be increased. This third strategy, however, which requires the use of more rinse water, runs counter to the objective of reduced water usage and thus will not be pursued here.

Spray Rinses and Rinse Water Agitation: Spray rinses and rinse water agitation can be used to create turbulence at the workpiece surface. A spray rinse alone may not provide sufficient cleaning for some workpieces, and therefore may be used in conjunction with an immersion rinse as described above under spray or fog rinses. Alternatively, workpieces can be agitated in the rinse water by moving the workpiece rack or creating turbulence in the water. Hand rack lines permit rack movement by the operator, with movement into and out of the rinse tank being most effective. The rinse water itself can be agitated with forced air or water. Air bubbles create the best turbulence for removing the process solution from the

workpiece surface [13], but misting caused by the air bubbles breaking at the liquid surface may result in air pollution.

Increased Contact Time: The feasibility of increasing the contact time between the workpiece and the rinse water will be different for each facility. Rotation plating increases contact time by allowing operators to leave workpiece racks in the rinse water while they handle other racks. Multiple rinse tanks also permit an increase in contact time, as discussed below.

Countercurrent Rinsing: Multiple rinse tanks can be set up in series in order to significantly reduce the amount of rinse water used. In countercurrent rinsing, the workpiece flow moves in the opposite direction to the rinse water flow. The rinse water overflow from the last tank is used as the feed to the preceding tank, and so on for the number of tanks in the series with only the overflow from the first tank going out of the system. The obvious limitation on the applicability of this method of rinse water reduction is the availability of floor space for the added tanks.

Flow Controls

Rinse water control devices can increase the efficiency of a rinse water system by eliminating excessive water use. Oversized piping permits the rinse water flow rate to be increased beyond that necessary for effective rinsing, which wastes water and therefore should be deterred. In addition, controls can be put in place to ensure that rinse water is not left running when the rinse tanks are not being used.

Flow Restrictors: Flow restrictors limit the volume of rinse water flowing through a rinse system by maintaining a constant flow of fresh water through a rinse system once the optimal flow rate has been determined. These restrictors can also be used upstream to ensure that operators must turn off unused rinse systems in order to operate another rinse system.

Conductivity-Actuated Flow Controllers: These devices control the fresh water flow through a rinse system by means of a conductivity sensor that measures the level of ions in the rinse water. When the ion level reaches a preset minimum, the sensor activates a valve that shuts off the flow of fresh water to the rinse system. When the concentration builds up to the preset maximum level, the sensor again activates a valve to resume the flow of fresh water.

Recycling/Recovery

Recycling and recovery technologies either directly use waste from one process as raw material for another process or recover valuable materials from a waste stream before they are disposed. Segregating waste streams is essential for most recycling and recovery technologies, since other wastes if mixed in can disrupt the reuse or

recycling process. The chemical properties of a waste stream must be understood in order to assess the potential for reuse/recycling or recovery.

Rinse Water: After rinse baths become too contaminated for their original purpose, they may be useful for other rinse processes. For example, the effluent from a rinse following an acid cleaning bath may be reusable as an influent to a rinse system following an alkaline cleaning bath (known as reactive rinsing). Reusing rinse water in this way can improve rinse efficiency by accelerating the diffusion process and reducing the viscosity of the alkaline drag-out film [13]. Care must be exercised to ensure that tank materials and pipes are compatible with the rinse solutions. The assessment team should evaluate the various rinse water requirements for their process lines and determine how they can take advantage of rinse water reuse opportunities that do not affect product quality.

Spent Process Baths: Typically, spent acid or alkaline solutions are dumped when contaminants exceed an acceptable level. However, these solutions may remain sufficiently acidic or alkaline to be useful as pH adjusters in the treatment operations. However, it is important to ensure that the process solutions are compatible before they are used in this manner. Alternatively, chemical suppliers may have reclamation services, some of which permit certain spent plating baths to be returned.

Solvents: Solvents can be recycled off-site as part of a package solvent service, which may be cost-effective for low volume users. High volume users of solvent cleaners can recycle solvent waste on-site using distillation technologies. Clean solvent is obtained after boiling and condensation, leaving only a still bottoms or sludge which must be handled as a hazardous waste.

APPENDIX J: PERTINENT LEGISLATION

APPENDIX J: PERTINENT LEGISLATION

Definitions

Policy A government policy is considered any program, plan or objective, and includes guidelines or criteria used in making decisions regarding proposals of instruments. Policies reflect the official position of a particular government ministry.

Regulatory Process

Acts - Broad legislation, identifying Regulations and Instruments

Examples: Ontario
- Environmental Protection Act (EPA)
- Ontario Water Resources Act (OWRA)
- Dangerous Goods Transportation Act

Federal
- Fisheries Act
- Canadian Environmental Protection Act (CEPA)
- Transportation of Dangerous Goods Act

Regulations - Provide a greater level of detail for implementation and administration of an Act.

Examples:
- Ont. Regulation 346 (Air)
- Ont. Regulation 347 (Hazardous Wastes)
- Ont. Regulation 102 (3Rs non-hazardous solid waste)
- Ont. Regulation 103 (3Rs non-hazardous solid waste)

Instruments - Refers to a licence, permit, Certificate of Approval, control order.

Examples:
- Approval for discharge into the natural environment other than water (i.e. air emissions) (Env. Protection Act, Section 9)
- Order to stop or regulate discharge of sewage into sewage works (OWRA Section 92)

Guidelines - Recommendations and statements of good engineering practices only, and are not legally enforceable.

Examples:
- Metal Finishing Liquid Effluent Guidelines (Environment Canada 1977)
- Guidelines for Decommissioning and Clean-up of Sites in Ontario

Voluntary Process

Voluntary programs are those in which industry voluntarily participates in order to stay ahead of the regulations, and communicate their efforts and achievements to the public.

Examples:

- The Metal Finishing Industry Pollution Prevention Project Memorandum of Understanding (MOU)
- Ontario Pollution Prevention Pledge Program (P4)
- Accelerated Reduction Elimination of Toxics (Aret)

ACTS

EPA

Environmental Protection Act (EPA)

This act protects and conserves the natural environment by regulating the discharges of contaminants to it. The Act defines the natural environment as any combination of air, land and water within the province.

The Act gives the Minister or Director appointed by the Minister the power to issue and enforce certificates of approval (C of A) and stop orders in the areas of waste management, waste hauling, and ozone depleting substances.

The regulations under this Act which can affect metal finishing/coating are:

General - Waste Management Regulation 347 (old 309)
General - Air Pollution Regulation 346 (old 306)
Waste Audits and Waste Reduction Work Plans - Reg 102 (3Rs)
Industrial and Commercial Source Separation Programs - Reg 103 (3Rs)

The guidelines under this Act which can affect metal finishing/coating are:

Guidelines for the Decommissioning and Cleanup of Sites in Ontario
Guidelines for Environmental Protection Measures at Chemical Storage Facilities

- Clause 14. Prohibition on discharge to the natural environment that could cause an adverse effect.

- Clause 9. Prohibition of the construction and operation of a plant if the discharge to the natural environment could cause an adverse effect without a certificate of approval.

(SPILLS BILL)

Spills Bill

Part X of the Environmental Protection Act addresses spills into the natural environment.

☐ **Concerns you if:**

• Your Facility stores chemicals outside the building or on a loading dock where there's a potential for a spill.
• A spill inside your building has potential to enter the environment or storm sewer

In this section, a spill is defined as the discharge of a pollutant
- into the natural environment
- from or out of a structure, vehicle or other container, and
- that is abnormal in quality or quantity in light of all the circumstances of the discharge.

This act does not apply to spills that occur within the confines of the building, where nothing is discharged to the environment or to a storm sewer.

Reporting

· Spills must be reported to the Ministry of Environment and Energy (MOEE) (district office) and the municipality.

Clean-up

· The owner or person in control of the pollutant that is spilled is responsible for cleaning it up and restoring the natural environment.

Due Diligence

· Section 87(3) states that " an owner of a pollutant or a person having control of a pollutant is not liable... if he establishes that he took all reasonable steps to prevent the spill of the pollutant..."

More Info?

▸ The Spills Bill, EPA Section X - Ontario Government Publications Outlet: (Toronto) 326-5300, (Toll Free) 1-800-668-9938

OWRA

Ontario Water Resources Act (OWRA)

This Act contains a general prohibition against the discharge of any material into water. Sections within the act describe as an offence the discharge of any material that impairs the quality of the water.

☐ **Concerns you if:**

• Your facility discharges to a sewer or directly to a water body.

The parts of this Act which can affect metal finishing/coating are:

Objectives for the Control of Industrial Waste Discharges in Ontario
Fees for Certificates of Approval Regulation (O. Reg 14/93)

- Clause 91. If a discharger makes arrangements with a municipality that are considered unacceptable by the Director or makes no arrangements, the Director may require the discharger to
  - make investigations and report
  - install facilities
  - operate such facilities

- Clause 92. If a discharger discharges sewage which may interfere with the proper operation of a sewage works, the Director may require the discharger to
  - stop or regulate such discharge
  - take action in accordance with an order

FISHERIES

Fisheries Act (Federal)

This Act is one of the oldest environmental statues in Canada and has been used for prosecutions relating to water pollution. The act prohibits the carrying out of a work that results in harmful alteration, disruption or destruction of fish habitat (section 35) or the deposit into water of a substance which is deleterious to fish.

☐ **Concerns you if:**

• Your facility discharges directly to a water body (not to a sanitary sewer)

Metal Finishing Liquid Effluent Guidelines and Code of Good Housekeeping Practices (1977)

The guidelines are intended to limit the discharge of deleterious substances in

effluents from the Canadian metal finishing industry for the protection of fish and other aquatic life. The guideline is a statement which indicates what practices will be considered by the Federal government to meet the intent of the Fisheries Act. The guideline is not a specific law.

The Code of Good Housekeeping Practices for the Metal Finishing Industry contains information on floor layout and construction, equipment protection, chemical substitution, water use, control of accidents, drainage and dragout, reclamation of process solutions and regeneration of plating baths.

TDG

Transportation of Dangerous Goods Act (Federal)

Dangerous Goods Transportation Act (Ont. Reg 261)

The Transportation of Dangerous Goods Act (TDG) was enacted to promote public safety during the handling, offering of transport, or transport of dangerous goods in Canada. The Ontario Act adopted the portions of the federal TDG which apply to road transportation.

☐ **Concerns you if:**

- Your facility transports goods which are Dangerous.

REGULATIONS / INSTRUMENTS

REG. 347 (Waste)

General - Waste Management Regulation (R.R.O., 1990, Reg. 347)
(formerly Reg. 309)

This regulation is aimed at tracking hazardous and liquid industrial wastes from their point of generation, through to their ultimate disposal

☐ **Concerns you if:**

- Your facility has hazardous or liquid industrial waste. Most metal finishing/coating companies have such waste (ie. wastewater treatment sludges, spent plating baths, paints).

"Metal finishing" in the regulation includes common and precious metal electroplating, anodizing, electroless plating, chemical etching and milling, chemical conversion coating (including colouring, chromating, phosphating and immersion plating) and printed circuit board manufacturing.

Generator - is the party responsible for creating the waste.
For example the finisher/coater who creates waste metal hydroxide sludge or waste solvents is considered a generator under Reg 347.

Carrier (transporter) - is the party who has been contracted by the generator and is licensed to transport the waste from the generators facility.
For example the trucking company that picks up the waste from the metal finisher/coater is considered the carrier.

Receiver - is the party that accepts waste from the carrier.

For example, a facility that accepts waste from the carrier and then treats and/or disposes of it is considered the receiver. The receiver must be licensed by the MOEE and must hold a Certificate of Approval (C of A).

Generator

The owner of the metal finishing/coating company is responsible for evaluating the wastes, and if the waste is found to be either hazardous or liquid industrial, registering them with the MOEE. What is *hazardous or liquid industrial waste*?

A waste is defined a *hazardous* if
- it is specifically listed in **Schedule 1,2,3, or 4** of the regulation
or
- it is **ignitable, corrosive, reactive, leachate toxic,** pathological, or contains PCBs.

A waste is defined as *liquid industrial* if:
- it is a liquid waste from industrial, commercial, manufacturing, research or experimental activities. Liquid wastes include wastes that are obvious liquids as well as those sludges that fail the *Slump Test*.

Some wastes from the metal finishing and coating industry are identified in Schedules 1 to 4

Schedule 1 Hazardous Industrial Waste from Non-Specific Sources

Industry & No.	Waste
NA9301	The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.
NA9302	The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, and trichloro fluoromethane; and the still bottoms from the recovery of these solvents. O.R. 507/93, s. 1.
NA9303	The following spent non-halogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol; and the still bottoms from the recovery of these solvents.
NA9304	The following spent non-halogenated solvents: cresols and cresylic acid, and nitrobenzene; and the still bottoms from the recovery of these solvents.
NA9305	The following spent non-halogenated solvents: toluene, methyl ethyl ketone, carbon disulphide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane; and the still bottoms from the recovery of these solvents. O. Reg. 240/92, s. 1; O.R. 507/93, s. 2.
NA9306	Wastewater treatment sludges from metal finishing operations except from the following processes: (1) sulphuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum.
NA9307	Wastewater treatment sludges from the chemical conversion coating (including colouring,

chromating, phosphating and immersion plating) of aluminum.

NA9308 Spent cyanide solutions from metal finishing operations (except for precious metals electroplating spent cyanide plating bath solutions).

NA9309 Metal finishing bath bottom sludges where cyanides are used in the process (except for precious metals electroplating bath sludges).

NA9310 Spent stripping and cleaning bath solutions from metal finishing operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions).

NA9311 Quenching bath sludge from oil baths from metal heat treating operations where cyanides are used in the process (except for precious metals heat treating quenching bath sludges).

NA9312 Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations (except for precious metals heat treating spent cyanide solutions from salt bath pot cleaning).

NA9313 Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process (except for precious metals heat treating quenching wastewater treatment sludges).

NA9314 Cyanidation wastewater treatment tailing pond sediment from mineral metals recovery operations.

NA9315 Spent cyanide bath solutions from mineral metals recovery operations.

A "hazardous waste chemical" means a commercial waste chemical that contains a commercial chemical product or manufacturing chemical intermediate of a specified generic name listed in Part B of Schedule 2.

but, except as specified in a), b), c) below, *it does not include a waste stream or waste material contaminated with material of the specified generic name*;

(a) an off-specification commercial chemical product or manufacturing chemical intermediate which, if it met specifications, would have the specified generic name,

(b) residues or contaminated material from the clean-up of a spill of a commercial chemical product or manufacturing chemical intermediate which, if it met specifications, would have the specified generic name, or

(c) an empty container or the liner from an empty container that contained a commercial chemical product or manufacturing chemical intermediate, or an off-specification commercial chemical product, or residues or contaminated materials from the clean-up of a spill of any of them, unless the empty container or the liner from the empty container has been triple rinsed,

Of note for metal finishers is that after a plating bath is used for awhile it becomes "off-spec" and then becomes a *hazardous waste*. But, rinsewater containing the specified chemicals is not a hazardous waste.

Schedule 2 Part A: Acute Hazardous Waste chemicals

For example, some of the chemicals listed are:

arsenic acid, arsenic trioxide & pentoxide,
all cyanide salts (barium, copper, nickel, silver, zinc...)
chlorotoluene ,
zinc phosphide (when present at concentrations greater than 10%)

Part B: Hazardous Waste Chemicals,

For example, some of the chemicals listed are:

acetone,
ethyl acetate, benzenes,
1 butanol,
chromic acid (calcium salt),
carbon tetrachloride,
chloroform,
cyclohexane,
cresyllic acid,
dichlorobenzene,
dichloromethane,
dimethylamine,
dioctyl phthalate,
formaldehyde,
isobutyl alcohol,
lead acetate,
lead phosphate,
methanol,
methyl ethyl ketone,
1,1,1,Trichloroethane,
methyl isobutyl ketone,
naphthalene,
2-nitropropane,
phenols,
1,1,2-trichloroethane,
trichloroethyene,
trichloroethylene,
toluene,
thallium acetate,
thiourea,
xylene,
zinc phosphide (when present at concentrations of 10% or less)

Leachate Toxic A Leachate Extraction test is described in the regulation. If the leachate contains any of the contaminants listed in Schedule 4 at a concentration in excess of one hundred times that specified in the Schedule, the material is leachate toxic.

Schedule 4 Leachate Quality Criteria

For example, wastes containing greater than

arsenic	0.05 mg/L
barium	1 mg/l
boron	5.0 mg/L
cadmium	0.005 mg/L
cyanide (free)	0.2 mg/L
lead	0.05 mg/L
selenium	0.01 mg/L
silver	0.05 mg/L

Ignitable	(for example ethanol, petroleum distillates, oxidizing substance)
Corrosive	(for example has a pH ≤2.0 or ≥12.5)
Reactive	(for example reacts violently with water, or generates toxic gases - sulphuric acid)

An industrial waste is *liquid* if it fails the **Slump Test**. The slump test involves placing the waste in question in a 30 cm open inverted cone. The cone is removed and the immediate decrease (slump) in the height of the waste material is measured. If the material slumps by more than half the height of the cone, the waste is liquid.

There is a small quantity exemption for liquid industrial waste of 25 litres per month. Another important exemption for only liquid industrial waste is:

> *Liquid industrial wastes or wastewaters that are discharged directly by a generator to a sanitary sewer that is located at the waste generation site are exempt. This exemption does not apply to Hazardous Wastes.*

If, after evaluating the waste, it is found to be hazardous or liquid industrial, the generator must register the waste with the MOEE.

Once the materials are completed and filed with the MOEE, the Ministry will provide the generator with a Generator Registration Number and waste numbers. Please note it takes the MOEE several weeks to issue a generator number , so start early if you know you have to dispose of a hazardous waste.

Whenever these wastes are transported off your site, they must be manifested. A manifest is a numbered document used to track waste from the generator through the receiver. You can get a blank manifest form the MOEE or the company you contract to haul your waste.
Neither hazardous nor liquid industrial waste can be stored at your facility for more than 90 days without permission form the MOEE. If you do store this waste for more than 90 days, you must notify the Regional Director of the MOEE within five days.

More Info?

‣ A copy of Ontario Regulation 347 and related information can be obtained from an Ontario Government Publications Outlet: (Toronto) 326-5300, (Toll Free) 1-800-668-9938

‣ Registration materials are available from a regional or district office. (SEE LIST at end of this appendix).

REG. 346 (Air)

General - Air Pollution Regulation (R.R.O. 1990, Reg. 346)
(formerly Reg. 308)

This regulation controls air pollution for stationary sources, covering air toxics, odours, and visible (particulate) contaminants.

☐ **Concerns you if:**

• Your facility has air emissions.

The Schedule which is part of the regulation lists 87 contaminants, unit of

concentration and the maximum half hour average allowable concentration of the contaminant that can be discharged to the outside air. For example, trichloroethylene is listed. The unit of measurement is micrograms of trichloroethylene per cubic meter of air. The maximum allowable concentration over a half-hour average is 85,000 ug/m^3. The point of measurement is called the point of impingement. This is often ground level, but the Regulation contains charts to help in calculating point of impingement.

If you suspect a problem with air emissions of some of the listed chemicals from the facility, you can contract with a company to perform outdoor air sampling around the facility.

More info?

▸ A copy of Ontario Regulation 346 and related information can be obtained from an Ontario Government Publications Outlet: (Toronto) 326-5300, (Toll Free) 1-800-668-9938

C of A (Air)

Certificate of Approval (C of A) - Air Emissions
(under Environmental Protection Act, section 8(1))

☐ **Concerns you if:**

• A Certificate of Approval must be obtained by any person who intends to:
-construct, alter, extend or replace any plant, structure, equipment, or thing from which a contaminant may be discharged into the natural environment other than water; or
- alter the process or rate of production with the result that a contaminant may be discharged into the natural environment other than water.

An exemption from the requirement to obtain a C of A that may affect metal finishers is routine maintenance carried out on any plant, structure or equipment;

To obtain a C of A, any or all of the following types of information may need to be provided:
- a complete description of the process
- a site plan
- zoning maps for the general area
- estimates of the maximum probable emission rates based on the testing of similar source, mass balances, fuel consumption and composition information, or other valid engineering data
- dispersion calculations using algorithms presented in the Appendix of Regulation 346
- comparison of Point of Impingement concentrations to guidelines/standards
- assurances that pollution control equipment will be maintained and the records kept for two years.

C of A (Wastewater)

Certificate of Approval (C of A) - Wastewater Discharges
(under Ontario Water Resources Act, section 24

☐ **Concerns you if:**

• Your facility is planning to construct or change a wastewater treatment system.

Prior to the establishment, extension, or change in sewage works, a Certificate of Approval. Sections 24(1) and 24(2) of the OWRA require:

1) No person shall establish, alter, extend or replace new or existing sewage works except under and in accordance with an approval granted by the

Director.

2) A Director may require an applicant for an approval to submit plans, specifications, engineer's report and other information and to carry out and report on tests or experiments relating to the location of the discharge of effluent or work to be undertaken.

Although operators of municipal wastewater treatment plants require certification, there is currently no similar requirement for operators of industrial wastewater treatment plants.

Model Sewer Use Bylaw (1988) and MISA

MISA Sewer Use

Sewer Use bylaws are established to protect the municipal sewer system, the health and safety of the sewer and sewage treatment plant workers, and the receiving waters to which the municipal sewage treatment plant discharges.

The 1988 Model Sewer Use Bylaw is part of the proposed MISA Sewer Use Control program. The Model contains lists of prohibited contaminants and restricted contaminants and their limits.

Sanitary sewers are those connected to a sewage treatment plant where wastewater is treated and then released back into the environment. Storm sewers, on the other hand, carry water directly to our rivers, lakes and streams without any treatment.

Municipal Sewer Use Bylaws

Control of discharges to sanitary and combined sewers and storm sewers. Requirements can include waste survey reports, compliance programs and agreements, sampling.

Control of Sanitary Sewers falls under the jurisdiction of municipalities. The provincial model is a guideline which municipalities can adopt or adapt to their specific needs.
As of November 1994, all major municipalities across Ontario have adopted the Model Sewer Use Bylaw.

☐ Concerns you if:

• If your facility is hooked up to the municipal sewer, you must comply with the sewer use bylaw.

1. Call your local municipal clerk's office and ask for a copy of the sewer use bylaw.

2. Find out if there are parameters in your facility wastewater effluent that are regulated in the sewer use bylaw.
   Have a sample taken at your property line and analyzed. The property line is that point where all the wastewater from your business is mixed together and enters the sewer main. The analytical lab can give you advice on sampling procedures.

More info?

‣ Your municipal clerk's office.

3Rs REG. 102

3Rs Regulations
Waste Audits and Waste Reduction Workplans Regulation
O. Reg. 102/94

The 3Rs Regulations (Reduce, Reuse, Recycle) apply to all non-hazardous solid wastes from residential and industrial, commercial and institutional (IC&I) sources.

Regulation 102 mandates a waste reduction program through waste audits and workplans.

☐ Concerns you if:

- Your facility is a manufacturing establishment with employees who work more than 16,000 hours in any one calendar month in any one year (this is approximately 100 employees)
- Your facility has office buildings with at least 10,000 square metres of floor area for use as offices

There are four steps to implementing the program required under the regulation.

1. Conduct a waste audit and prepare a written report. The audit must address
   - the amount, nature and composition of the waste generated
   - how the waste is produced, including relevant management policies and practices
   - how the waste is managed
2. Develop a waste reduction workplan using the information from your waste audit. The written workplan must be posted.
3. Implement the waste reduction workplan
4. Update the audit and workplan at least once per year

An establishment that comes into existence after March 3, 1994 and is above the size threshold, will have six months to comply.

An establishment that increases its size above the size threshold on a date after March 3, 1994, will have six months to comply.

More Info?

▸ The MOEE has sample guidelines and forms available from the Ministry's Regional and District Offices. (SEE LIST at end of this appendix)

3Rs REG. 103

3Rs Regulations
Industrial, Commercial and Institutional Source Separation Programs Regulation, O. Reg. 103/94

Regulation 103 mandates large generators to separate specific reusable and recyclable waste materials from other types of waste at the place where the wastes were created.

☐ Concerns you if:

- The size of your facility falls under the 3Rs Regulation 102 requirements.

Metal finishing/coating facilities would most likely fit in the *Large manufacturing establishments,* or *Office buildings*.

Materials that must be in source separation programs for *large manufacturing establishments* are:

1. Aluminum.
2. Cardboard (corrugated).
3. Fine paper.
4. Glass.
5. Newsprint.
6. Polyethylene (high density) jugs, pails, crates, totes and drums.
7. Polyethylene (linear low density and low density) film.
8. Polystyrene (expanded) foam.
9. Polystyrene trays, reels and spools.
10. Steel.
11. Wood (not including painted or treated wood or laminated wood).

Materials that must be in source separation programs for *Office buildings*

1. Aluminum food or beverage cans (including cans made primarily of aluminum).
2. Cardboard (corrugated).
3. Fine paper.
4. Glass bottles and jars for food or beverages.
5. Newsprint.
6. Steel food or beverage cans (including cans made primarily of steel).

There are four requirements.

1. There must be adequate facilities for collecting, handling and storing the anticipated quantities of the source-separated wastes.
2. The collected wastes must be removed.
3. Information about the program must be given to users and potential users. The information describes how to participate in the program, how well it is working and encourages full use of the program.
4. The waste generator must make reasonable efforts to ensure that the separated waste is reused or recycled.

Manufacturing establishments under the regulation must have a source separation program in place by March 3, 1995.

More Info?

▸ A copy of Ontario Regulation 103/94 and related information can be obtained from an Ontario Government Publications Outlet: (Toronto) 326-5300, (Toll Free) 1-800-668-9938

▸ Training programs are available through local community colleges: Ontario Environmental Training Consortium
1-800-563-6555 or (905) 575-2430.

National Pollutant Release Inventory (NPRI) (Federal)

NPRI

The National Pollutant Release Inventory (NPRI) is a publicly accessible inventory of specified substances that Canadian industry, government and commercial facilities release to the air, waster and land or transfer off-site. Facilities who qualify for the NPRI are required to report to the federal government how much of these substances they have released or transferred off-site.

☐ Concerns you if:

• In general, any person who owns or operates a facility must report on the NPRI if:

- the facility has 10 or more full-time employees or the equivalent of part-time employees,
<u>and</u>
- the facility has manufactured, processed, or used 10 tonnes or more of a listed substance in the calendar year
<u>and</u>
- the concentration of a listed substance is greater than or equal to 1% by weight.

The companies must report
- on-site releases
  - air releases (stack, storage/handling, fugitive, spills, other non-point)
  - underground injection
  - surface waters (direct, spills, leaks)
  - land (landfill, landfarm, spills, other)
  - total release
  - anticipated releases in future years

- off-site transfers
  - recovery/reuse/recycle
    - *but **not** material that is sold to a recycler*
  - destruction (incineration, etc.)
  - sewage treatment plants
  - containment (landfill, etc.)
  - anticipated transfers in future years

It contains
- 13 inorganic elements and their compounds (metals)
- 18 inorganic substances (acids, chlorine, etc.)
- 11 Qualified organic substances (cresol, xylene and colorants)
- 32 halogenated organic substances (carbon tetrachloride, chlorobenzene, etc.)
- 100 non-chlorinated organic substances
  - aromatic hydrocarbons (benzene, toluene, etc.)
  - other hydrocarbons (ethylene, etc.)
  - nitrogen containing substances (aniline, diisocyanate)
  - sulphur containing compounds (thiourea, etc.)

More Info?

▸ Environment Canada - Ontario Region, NPRI coordinator (416) 973-1085

Ozone Depleters (CFCs, etc.)

☐ Concerns you if:

Solvents Containing Ozone Depleting Substances (O. Reg 717/94)

• Your facility uses solvents containing ozone depleting substances.

This regulation under the Ontario EPA controls solvents containing ozone depleting substances. As of January 1, 1996, it bans the production of solvents containing CFCs, carbon tetrachloride and methyl chloroform. Discharge, use and transfer of these substances is prohibited after July 1, 1996, and storage after July 1, 1998. As of January 1, 2000, it bans the production of solvents containing HCFCs.

Halon Fire Extinguishing Equipment (O. Reg. 413/94)

Prohibits the discharge of
halon 1211 (bromochlorodifluoromethane),
halon 1301 (bromotrifluoromethane) and
halon 2402 (dibromotetrafluoroethane),
except in fire extinguishers.

Ozone Depleting Substances Regulations (Federal)

- fully halogenated CFCs and other CFCs
  - restrictions on manufacture and use (January 1989)
  - prohibit use (proposed January 1996)

- carbon tetrachloride and methylene chloride
  - restrictions on manufacture, use and import/export (January 1995)
  - prohibit manufacture, use and import/export (January 2000)

Noise

☐ Concerns you if:

Municipal Noise By-laws

• Your facility has had a complaint of noise from neighbours or is installing machinery that has the potential to disturb neighbours with noise.

Sound and vibration are defined as contaminants under the Ontario EPA, and they are prohibited from discharge if they bother neighbours of the facility.

The MOEE published a Model Noise By-law (1978) which includes Noise Pollution Control documents which describe guidelines for noise levels, assessments , monitoring and abatement.

Site Cleanup

☐ Concerns you if:

Guidelines for the Decommissioning and Cleanup of Sites in Ontario

The Guidelines detail a process for meeting MOEE requirements and outline management and technical procedures in this regard.

• This process affects all metal finishers as the liability for future cleanup of a contaminated site can be put on previous owners of the site. If you are planning to purchase a new site, new owners can also be held liable for cleanup of past contamination at the site.

The term decommissioning means mothballing, partial closure or complete closure of the facilities.

The term clean-up means the restoration of a contaminated site to ensure the protection of human health and the environment.

The Guideline appendix lists clean up criteria based on land use for different parameters (metals, etc.).

Guidelines for Environmental Protection Measures at Chemical Storage Facilities

Chemical Storage

The purpose of these guidelines is to provide assistance to MOEE staff in the assessment of environmental protection measures at existing chemical product storage facilities and in the development and approval of such measures at new installations (includes drum storage).

Objectives for the Control of Industrial Waste Discharges in Ontario

Objectives for discharge

The MOEE requires all industries discharging wastes to public waters to undertake effluent improvement programs to meet the specified objectives. Desirable effluent discharge concentrations are listed for BOD, suspended solids, oils and greases, metals, phenols, toxics, ammonia, pH, sulphate, chlorides and dissolved solids, taste and odour, temperature and aesthetic qualities.

POLICIES

Ontario Water Management Policies

Water Management

For the development of effluent requirements, the publication Water Management - Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy, 1994 (MOEE, 1994) is the primary document used to provide interpretation of the legislation. Surface water quality management is addressed under a series of Surface Water Management Policies and the Provincial Water Quality Objectives (PWQO)

Provincial Water Quality Objectives (PWQO)

(PWQO)

PWQO provide guidance in making water quality management decisions. They are often used as the starting point in deriving waste effluent requirements included in Certificates of Approval.

Surface Water Quality Policies

1) In areas which have water quality better than the Provincial Water Quality Objectives (PWQO), water quality shall be maintained at or above the Objective.
2) Water quality which presently does not meet the PWQO shall not be further degraded an all practical measures shall be undertaken to upgrade the water quality to the Objectives.
3) Prevent the release, in any concentration, of hazardous substances that have been banned.
4) Ensure that special measures are taken on a case by case basis to minimize the release of hazardous substances that have not been banned.

UPCOMING REGULATORY ISSUES

Sewer Use Regulation (Ontario)

Sewer Use Reg.

The MOEE is currently drafting a new Sewer Use Regulation, that is expected to be available in draft form in September 1995.

A Joint Technical Committee, comprised of government, industry and environmental groups is working on the draft regulation. The metal finishing industry is represented on this committee by the Canadian Association of Metal Finishers (CAMF), and the Canadian Manufacturing Association (CMA).

Canadian Council of Ministers of the Environment (CCME) NO_x/VOCs

CCME NOx/VOCs

Metal cleaners, degreasers and paints used in metal finishing may contain volatile organic compounds (VOCs) that are released from the evaporation of solvents. VOCs along with nitrogen oxides (NO_x) react in the presence of sunlight to form ground level ozone (smog).

In November 1990, the Canadian Council of Ministers of the Environment released Phase 1 of a three phase plan to control NO_x/VOCs, especially for the smog problem area of the Windsor-Quebec Corridor.

While the regulatory process to implement these initiatives will not be ready for some time, metal finishers and coaters can begin to prepare by voluntarily reducing VOCs. Work with your chemical and equipment suppliers to ensure you're using the lowest VOC products practical.

V309 New Source Performance Standards (NSPS)
Commercial/industrial degreasing
V614 Retrofit existing commercial/industrial degreasing

- Reference Document for VOC emissions from solvent degreasing (draft document September 1993)
- Environmental Code of Practice for the reduction of solvent emissions from NSPS commercial and industrial degreasing facilities (draft document January 1994)
- Pollution prevention focused initiatives

V307 NSPS Commercial and industrial coating applications
V612 Retrofit existing surface coating facilities

- Solvent reduction technologies and other emission reduction options report (draft document June 1993)
- Pollution prevention focussed initiatives
- Emissions inventory repot (draft document December 1993)
- Development of an environmental code of practice/guideline (NSPS) (initiated in March 1994)

V302 NSPS - Volatile liquid storage tanks

V606 Retrofit Volatile liquid storage tanks

- CCME guideline for existing and new sources (draft document May 1993)
- Pollution Prevention focused initiatives

Environmental Bill of Rights

EBR

By November 15, 1994, all new approvals (e.g. C of A), policies and regulations of the MOEE will be subject to the advance public notice and comment provisions of the Bill.

An electronic bulletin board containing all this information can be accessed through any modem at (416) 327-3000.

VOLUNTARY INITIATIVES

Pollution Prevention Pledge Program

P4

Designed to encourage industry and government facilities to voluntarily extend environmental protection efforts through pollution prevention.

☐ Concerns you if:

- You want to receive recognition for your commitment to pollution prevention for use as a marketing tool with customers, suppliers and the public.
- You want to support voluntary initiatives over regulatory controls.

There are four levels of participation
- P1 registration and planning
- P2 reduction commitment pledge
- P3 reduction achievement
- P4 Pollution prevention achievement

Memorandum of Understanding

MOU

Metal Finishing Industry Pollution Prevention Project
(with industry associations (CAMF, AESF, MFSA, APMA, AAC), Environment Canada, Ontario Ministry of Environment & Energy.

- simplified assessment and planning manual for small industries
- development and implementation of pollution prevention plans
- develop a target list of substances
- provide on-site technical assistance
- provide training, clean technology program

SUBSTANCES OF ENVIRONMENTAL CONCERN IDENTIFIED BY GOVERNMENTS

LISTS

• As a metal finisher or coater , if you use substances on these lists, you can expect to find increasing pressure for substitutions and stricter controls.

☐ Concerns you if:

Candidate Substances for Bans, Phase-outs or Reductions- Multimedia Revision, (Ontario MOEE, 1993)

Bans, Phase-outs

There are 27 substances described on the primary list and 63 substances on the secondary lists. The lists are based on specific criteria (persistence, bioaccumulation, toxicity including acute lethality, chronic toxicity and carcinogenicity).

Canada Ontario Agreement (COA)

COA

In July, 1994 , Environment Canada and the Ontario Environment and Energy signed a new six-year Canada-Ontario Agreement (COA) calling for co-ordinated action to restore, protect and sustain the Great Lakes Basin ecosystem.

The Agreement includes virtual elimination of 13 persistent, bioaccumulative and toxic substances from the Great Lakes Basin and reduction at source of another 26 pollutants of concern in the Great Lakes. These two lists are referred to as Tier I and Tier II list.

Towards a Toxic Management Policy for Canada, Environment Canada
Draft 1994.
Similar to the Ontario Bans, Phase-outs and Reductions, and the work initiated in the Canada Ontario Agreement.
There are two streams for chemical identification:

1) if the chemical meets the three criteria of: man-made, bioaccumulative, persistent toxics, then it is targeted for virtual elimination - no measurable release to the environment.
2) if the chemical meets any one of the criteria: man-made, bioaccumulative, persistent toxics then: it is targeted for management from "cradle to grave".

Strategic Option Process (SOP)

SOP

The federal Ministers of Environment and Health have identified hexavalent chromium, inorganic cadmium and oxidic, sulphidic and soluble inorganic nickel compounds in the metal finishing sector. A SOP is being set up to develop recommendations to the federal Ministers on options to deal with these substances.
Other substances identified in the SOP for degreasing are:
· dichloroethane; 1,2-dichloromethane; (bis-2) ethyl hexyl phthalate; PAHs; tetrachloroethylene; trichloroethylene.

Ministry of Environment & Energy - Regional and District Offices (December 1994)

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Toronto, Ontario M4H 1A8
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Halton-Peel District Office - Central Region
1235 Trafalgar Rd, Suite 401
Oakville, Ontario L6H 3P1
Fax No: 905-842-1750
Phone No: 905-844-5747

York-Durham District Office - Central Region
7 Overlea Blvd., 4th Floor
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MID ONTARIO REGION

Sudbury Regional Office - Mid Ontario Region
199 Larch St., Suite 1101
Sudbury, Ontario P3E 5P9
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North Bay District Office - Mid Ontario Region
Northgate Plaza
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Phone No: 705-476-1001

Barrie District Office - Mid Ontario Region
54 Cedar Point Drive
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74 Church St.
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483 Bethune Drive N.
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Phone No: 705-687-6647

Sudbury District Office - Mid Ontario Region
199 Larch St., 11th Floor
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Thunder Bay Regional Office - Northern Ontario Region
435 James St. South, Suite 331 Thunder Bay,
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Fax No: 807-475-1754
Phone No: 807-475-1205

Kenora District Office - Northern Ontario Region
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808 Robertson St.
Kenora, Ontario P9N 1X9
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Phone No: 807-468-2718

Sault Ste. Marie District Office - Northern Ontario Region
747 Queen St.
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Fax No: 705-945-6868
Phone No: 705-949-4640

Timmins District Office - Northern Ontario Region
83 Algonquin Blvd. West
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Fax No: 705-264-7336
Phone No: 705-268-3222

Thunder Bay District Office - Northern Ontario Region
435 James St. South, Suite 331 Thunder Bay, Ontario P7E 6E3
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Phone No: 613-549-4000

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2435 Holly Lane
Ottawa, Ontario K1V 7P2
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Phone No: 705-743-2972

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Owen Sound District Office - Southwestern Region
1180 - 20th St. East
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Fax No: 519-371-2905
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Sarnia District Office - Southwestern Region
1094 London Rd.
Sarnia, Ontario N7S 1P1
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Phone No: 519-336-4030

Windsor District Office - Southwestern Region
250 Windsor Ave., 6th Floor
Windsor, Ontario N9A 6V9
Fax No: 519-254-5894
Phone No: 519-254-2546

WEST CENTRAL REGION

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119 King St. West
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